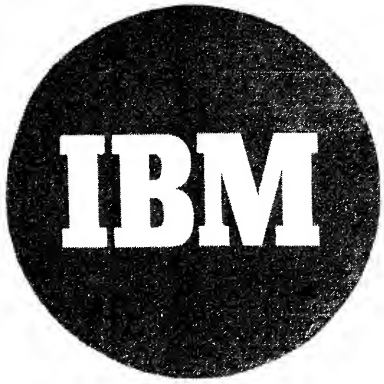

data processing

650 magnetic drum data-processing machine

MANUAL OF ADDITIONAL FEATURES:

- magnetic tapes
- high-speed storage
- printer

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manual of operation

preliminary edition

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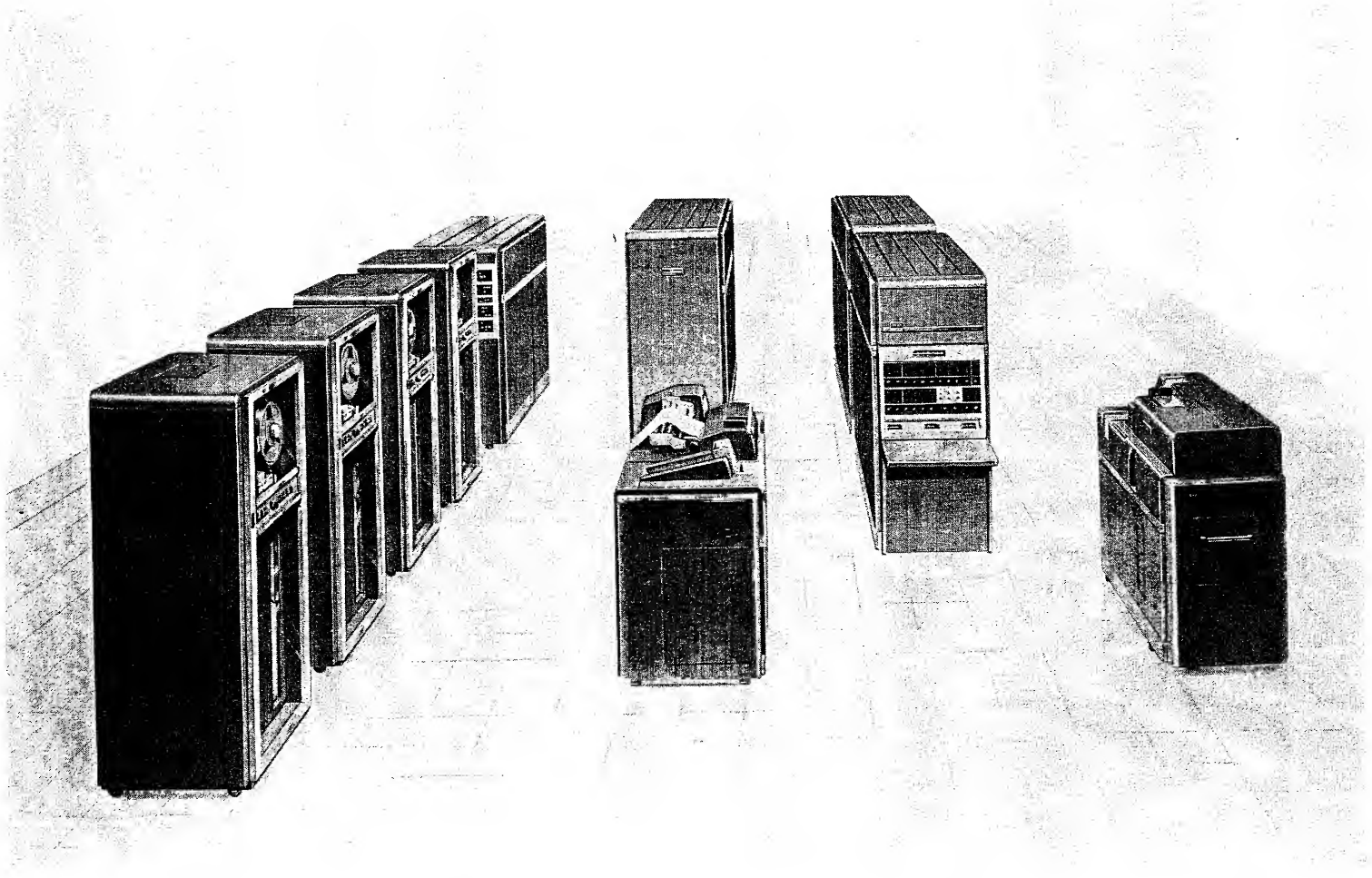


Type 727(4) Type 652 Type 653 Type 407 Type 655 Type 650 Type 533

Type 650 with Additional Features — Magnetic Tapes, High-Speed Storage, Printer

TYPE 650 ADDITIONAL FEATURES

Magnetic Tapes • High-Speed Storage • Printer

THE ADDITION of the high-speed storage unit, magnetic tape units, and the Type 407 Accounting Machine to the Type 650 Magnetic Drum Data Processing Machine greatly increases the scope of applications for this equipment.

The high-speed storage unit provides a means of increasing the operational speed of the Type 650, as well as the link connecting the magnetic tapes to the system. Magnetic tapes provide access to large files of historical or current data. The Type 407 Accounting Machine provides a direct printed output for data from the magnetic drum or from high-speed storage. Data from cards in the Type 407 may be read into the magnetic drum or the high-speed storage unit for processing or for output.

Inventory records, insurance plans and policy data, payroll employee records, installment loan accounts, public utility rate structures, manufacturing schedules and requirements are typical of the type of data that the Type 650 can now process faster and in a more integrated manner.

A complete tape-printer system consists of the Type 650, the Type 407 Accounting Machine, 6 magnetic tape units and a high-speed storage unit as follows:

Type 650	Console Unit
Type 655	Power Unit
Type 533	Read-Punch Unit
Type 407	Accounting Machine
Type 727	Magnetic Tape Unit (maximum 6)
Type 652	Control Unit
Type 653	Auxiliary Unit (High-Speed Storage)

In addition to these units, a summary punch can be connected to the Type 407 Accounting Machine.

Type 407 input-output data are transferred directly to and from the magnetic drum or high-speed storage. Two sources of card data are now available to the Type 650: The Type 407 feed and the Type 533 feed. Master cards can be placed in one feed, and detail cards, in the other. A file of cards in random sequence can be placed in both feeds to increase the rate of card input.

The high-speed storage unit is magnetic core storage that acts as a buffer between the tape units and the rest of the system. This core storage is also available for use as an extension of general storage, because each word is addressable and can be used for all Type 650 operations, including table lookup. Use of core storage results in considerable time saving, because immediate access to data and instructions is provided.

All standard Type 650 operations and the flexibility of stored programming are retained. Therefore, the Type 650 Manual of Operation, Form 22-6060, should be studied before using this manual, which describes only the additional features.

TAPE OPERATION

THE MAGNETIC TAPE used by the Type 650 is the standard tape presently in use by the Electronic Data-Processing Machines. On this plastic tape, one-half inch wide, 200 characters are stored per inch of length. Processed by the Type 727 Magnetic Tape Unit, the tape is read or written at the rate of 75 inches per second.

Information on tapes may take the form of data or instructions. All information is stored on the tape in the 7-bit code presently used by the Type 705 (Figure 1). The output from the Type 650 is automatically converted from the internal code to the 7-bit code for writing. Conversion on reading from the 7-bit code to the internal coding is also automatic. This code permits interchange of tapes between the Types 702, 705, and the 650, providing the records on the tape are in a word form acceptable to the 650. Independent operation of peripheral 700 series equipment from 650 tape will need individual investigation to determine its feasibility.

The flexibility of variable record length is provided through the use of the high-speed storage unit. Tape records of from one to sixty words enable the Type 650 to handle the varying requirements of many different applications.

Records may also be grouped and handled by a single read or write instruction but retaining the ability to process each record separately. A maximum size record group consists of 60 words.

Alphanumerical data from the Type 650 may be written on tape in two ways: two-digit numerical representation for each character; or single-character alphanumerical form.

The two-digit numerical representation is the simplest to use, because it keeps the alphanumerical characters in the same form as they are used on the Type 650 drum and in high-speed storage. In this way a 300-character alphabetic record (represented as 600 numerical characters) can be written as one tape record. A mixed record of alphabetical characters (in two-digit representation) and numerical characters (in single-digit representation) can be tape-processed in the same fashion.

Some installations may require that tape records from the Type 650 be compatible in representation for processing on Type 705 data-processing machines. Two operation codes in the Type 650 provide for reading and writing an alphanumerical character in single-character representation on tape. This automatic conversion to and from Type 650 two-digit representation and single-character representation takes place between the high-speed storage unit and the tape control unit. This method requires that the alphanumerical record be composed of ten-word blocks. The conversion between two-digit and single-character representation is determined by an alphabet control word. One alphabet control word is needed for each ten-word block. The alpha-control word specifies which of the other 9 words of the same block are alphanumerical and which are numerical. In this manner alphabetic data (two-digit representation) is converted to single-character Type 705 code, and numerical data (single-digit representation) is kept in single-digit form.

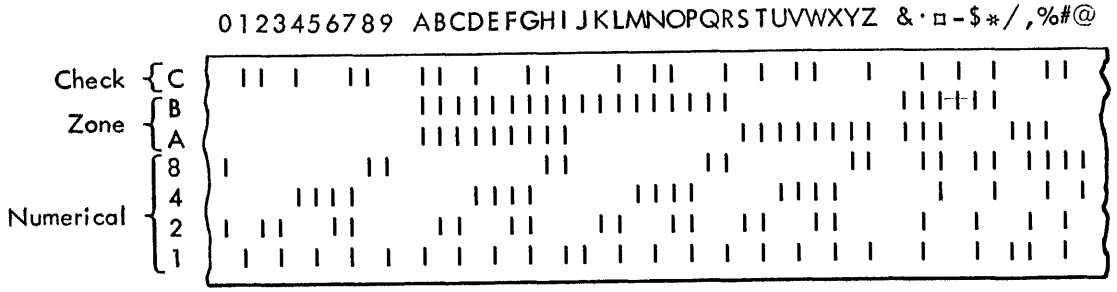


FIGURE 1. TYPE 705 MAGNETIC TAPE CHARACTER CODING

TYPE 727 MAGNETIC TAPE UNIT

UP TO SIX Type 727 Magnetic Tape Units may be attached to the Type 650 at a time. These tape units are capable of either reading or writing and may be used as input or output in any combination, such as three units for input and three units for output. To permit this type of operation, each tape unit is assigned an address. Therefore, by means of programming, the tape unit desired is easily selected. These tape unit addresses are:

8010
8011
8012
8013
8014
8015

The units position of each address, 0 through 5 is set on a dial on the front of each tape unit. This permits each of the tape units to fulfill the address requirements of any program. When desired, two tapes may be written simultaneously by setting the same address on two tape units. However, this operation limits checking of the write operation.

When a read or write instruction is executed, 3/8" of tape is required for acceleration to the proper tape reading or writing speed, and 3/8" of tape is required for deceleration of the tape to a stop. The tape distance required for starting and stopping time provides an inter-record-gap (IRG) of 3/4". Therefore, the tape required for a read or write operation is dependent upon the length of the record plus the inter-record-gap (3/4"). For 60 words (600 numerical characters), three inches of tape are required in addition to the 3/4" gap. This results in storing over 7,600 records of 600 numerical characters each on one reel of tape 2,400 feet in length or 23,000 ten-word records.

TYPE 652 CONTROL UNIT

THE TYPE 727 Magnetic Tape Units are connected to the high-speed storage unit through the Type 652 tape control unit. This control unit is used to provide power and control signals and need not be considered in the writing of programs. Through this control unit, either a read or write condition may exist at any time. However, there is no provision for simultaneous reading while writing.

TYPE 653 AUXILIARY UNIT

THE READING and writing of tapes take place only to and from high-speed storage of the 653 Auxiliary Unit. This storage unit consists of a 600-digit (60-word) buffer composed of magnetic-core storage. The 60 words of high-speed storage are assigned the addresses 9000 through 9059.

This high-speed storage provides for entry and exits of 60 words for reading and writing tape. Being addressable, it is also usable as an extension of general storage for all Type 650 operations. Because of the low access time of core storage, this buffer provides high-speed storage for data and instructions. Transfer to and from high-speed storage is accomplished by the following methods:

TO THE HIGH-SPEED STORAGE

1. Directly from any input device through the input storage area.
2. One word transfers from the distributor and accumulator.
3. Block transfers from general storage.

FROM THE HIGH-SPEED STORAGE

1. Directly to any output device through the output storage area.
2. One word transfers to the distributor, accumulator, or program register.
3. Block transfers to general storage.

This flow of information is illustrated in Figure 2 and further explained under *Flow Paths*.

FLOW PATHS

THE FLOW PATHS in Figure 2 indicate the flow of information throughout the Type 650, as well as to and from the tape units and the high-speed storage unit. The points on the diagram labelled V.C. are the validity check points in the system.

Information flow of one word at a time (to and from the high-speed storage) is handled by the Type 650 operation codes, such as load distributor, reset add lower, store upper, etc. For this type of operation, the high-speed storage unit is being used as an extension of general storage.

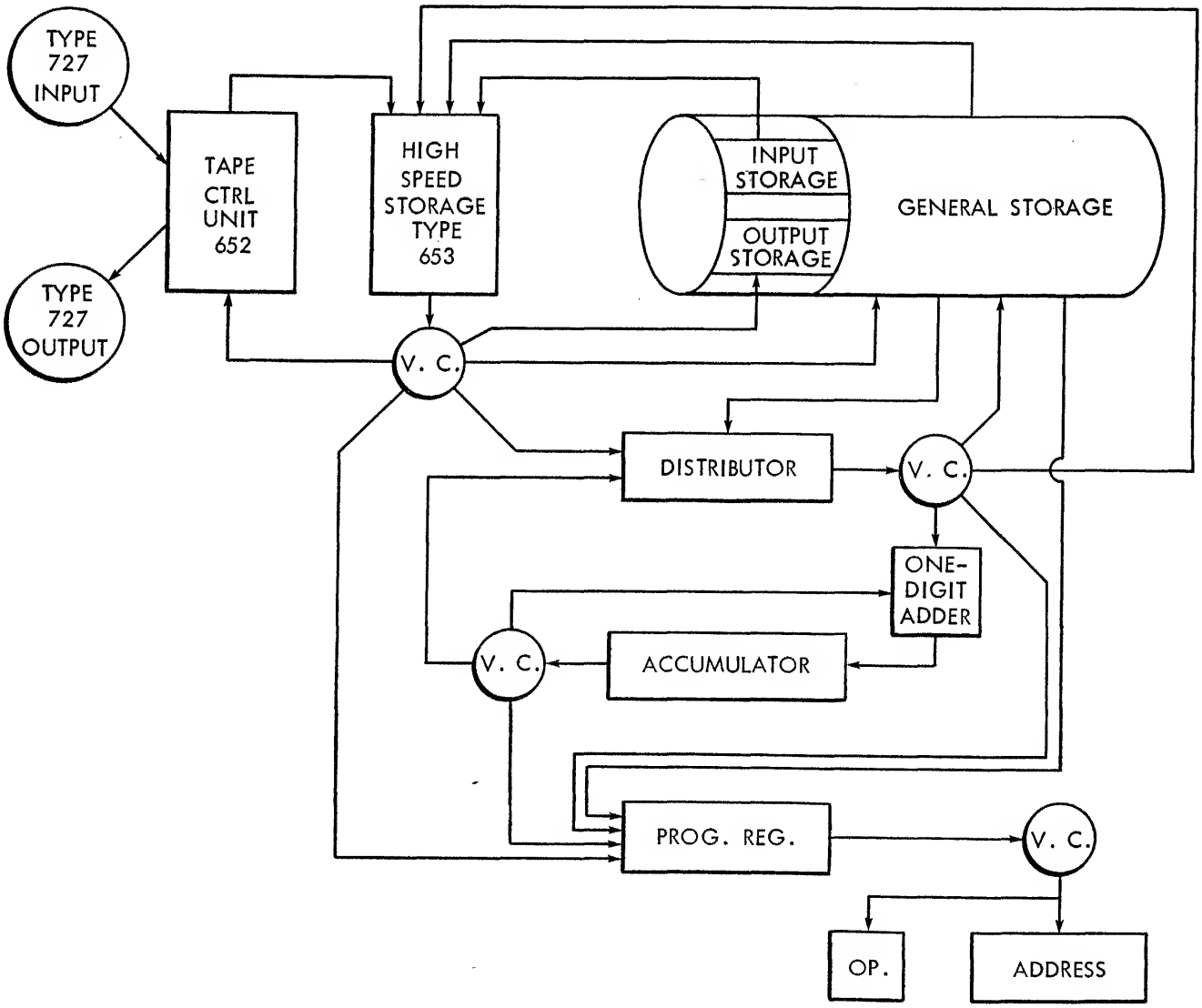


FIGURE 2. SCHEMATIC OF FLOW PATHS

Information flow to and from the buffer (high-speed storage) in blocks of words is handled by the codes load buffer, load buffer block, store buffer, and store buffer block. In addition to these codes, it is possible to enter information from any input unit through the input storage area directly to high-speed storage. It is also possible to go from high-speed storage to any output unit. These operations are handled by the normal input and output codes 70-78.

OPERATION CODES

Tape Reading

Records read from a tape are automatically entered into the high-speed storage unit. The size of the record, variable from 1 word to 60 words, must be known so high-speed storage can be set to accept a record of that size. The record enters high-speed storage beginning with a predetermined word and con-

tinuing through word 9059. The record from the tape must exactly fill high-speed storage from the predetermined starting point through word 9059. If the tape record is either too long or too short, an error is indicated and the machine stops. The following codes are provided for tape reading.

03, Read Check Tape (RCT). A record is read from the tape unit specified by the data address. This record is not transferred into high-speed storage but is checked for character validity.

04, Read Tape (RT). A numerical record is read from the tape unit specified by the data address. This record is transferred into high-speed storage and is checked for valid character coding and over-all record validity. The record from the tape fills high-speed storage beginning with a predetermined word as specified by the program.

05, Read Tape Alphanumerical (RTA). An alphanumerical record is read from the tape unit specified by the data address. This record is read into high-speed storage and is checked for valid character coding and over-all record validity. All alphanumerical records must be a multiple of 10 words in length, such as 10, 20, 30, etc. In an alphanumerical tape record the first word of each group of 10 is the control word for that group, and it specifies which of the following 9 words are alphabetic and which are numerical. These control words will be read into words 9009, 9019, 9029, etc. Each alphabetic character is stored in high-speed storage and on the drum as a two-digit number. Therefore, in each group of 10 words there may be a maximum of 45 alphabetic characters in addition to the control word. A 60-word record from the tape fills high-speed storage by placing the first alpha-control word in location 9009, and the following 9 words from tape in locations 9000-9008. The second alpha-control word is placed in location 9019, and the following 9 words are placed in locations 9010-9018, etc.

Tape Writing

All tape records are written from the high-speed storage unit. The size of the records may vary from 1 word through 60 words. The size of the record is determined by specifying the point in high-speed storage from which writing is to take place. Writing will continue from the starting point through word 9059.

06, Write Tape (WT). A numerical record is written from high-speed storage onto the tape unit specified by the data address. The record is written beginning with a specified location in high-speed storage as determined by the program. Writing continues through location 9059.

07, Write Tape Alphanumerical (WTA). An alphanumerical record is written from high-speed storage onto the tape specified by the data address. Writing must take place beginning with word 9000, 9010, 9020, etc. This is determined by the program. When this code is used, the tenth and every tenth word following is the control word for the nine words that precede it. Because alphabetic and special characters require two positions of storage, a maximum of 45 alphanumerical characters plus the 10 numerical characters in the control word may be written for each ten words of high-speed storage. Writing will continue from the specified starting point through location 9059.

High-Speed Storage

The 60 words of high-speed storage are divided into six groups of ten words each, 9000 through 9009, 9010-9019, etc.

Because the operation being performed may call upon a block of words in high-speed storage, a device known as a timing ring is used. This timing ring keeps track of the word that is being operated upon. For example, when a read from tape unit 8010 is programmed, the timing ring determines the starting word in the high-speed storage unit. This timing ring is set to any of the addresses 9000 through 9059 by the three following methods:

1. A one-word transfer calling on high-speed storage sets the timing ring at the data address of the instruction. For example, load distributor from 9004 (69 9004 XXXX) sets the timing ring at 9004. The ring remains set at 9004 until some other operation involving high-speed storage changes the ring setting.

2. A block transfer to or from high-speed storage leaves the ring at the address of the last word transferred plus 1. For example, assume the ring to be at

9004, and a read tape unit 8010 is programmed. The record from tape will fill high-speed storage beginning with 9004 and continue through 9059. The ring will be left at 9059 plus 1 or 9000, the ring being completed from 9059 to 9000.

3. A set buffer command to be explained in this section will set the ring at any address desired.

27, Set Buffer (SET). This operation code sets the timing ring in high-speed storage at the data address of the instruction. This code normally precedes an instruction referring to high-speed storage unless the instruction has a D-address of 90XX. It permits the programmer to select the starting point of the succeeding operation. For example, when a set buffer at 9051 is followed by a write onto tape unit 8011, writing begins with word 9051 and continues through 9059, leaving the timing ring at 9000.

08, Load Buffer Block (LBB). Load high-speed storage with a maximum of 10 words from general storage. The first of the words from general storage is specified by the data address of the instruction. The first word of high-speed storage is determined by the address of the timing ring set by some previous instruction. The loading operation is completed when the end of a band in general storage is reached, or when the end of one of the groups in high-speed storage is reached, whichever occurs first. For example:

```
SET (27) 9015 XXXX
LBB (08) 1847 XXXX
```

This results in words 1847 through 1849 being transferred to locations 9015 through 9017. The timing ring is left at 9018. If the following load buffer block instruction is then given,

```
LBB (08) 1240 XXXX
```

words 1240 and 1241 will be transferred to 9018 and 9019. The timing ring is left at 9020.

09, Load Buffer (LB). Load high-speed storage with a maximum of 50 words from general storage. The first of the words from general storage is specified by the data address. The location of the first word in high-speed storage is determined by some previous operation referring to the buffer, such as a set instruction. The load operation is completed when the end of the band in general storage is reached or by reaching the end of high-speed storage. For example:

```
SET (27) 9000 XXXX
LB (09) 1000 XXXX
```

The 50 words (1000 through 1049) are loaded in locations 9000 through 9049 in high-speed storage. The timing ring is left at 9050. Assume these instructions were followed by

```
LB (09) 1050 XXXX
```

Words 1050 through 1059 would load into 9050 through 9059. The timing ring would be left at 9000.

28, Store Buffer Block (STBB). A maximum of 10 words of high-speed storage is stored in general storage. The location of the first word in high-speed storage is determined by the timing ring. The location of the first word in general storage is specified by the data address of the instruction. The store instruction is completed when the end of a group in high-speed storage is reached (such as 9009) or the end of a band in general storage is reached, whichever occurs first. For example:

```
SET (27) 9015 XXXX
STBB (28) 1004 XXXX
```

Words 9015 through 9019 will store in locations 1004 through 1008. The ring will be left at 9020. Assume these two instructions are followed by

```
STBB (28) 1147 XXXX
```

Words 9020 through 9022 will store in 1147 through 1149. The ring will be left at 9023.

29, Store Buffer (STB). A maximum of 50 words of high-speed storage is stored in general storage. The first word to be stored is determined by the setting of the timing ring. The location of the first word in general storage is specified by the data address of the instruction. The store operation is completed when the end of a band is reached or when the end of high-speed storage is reached, whichever occurs first. For example:

```
SET (27) 9000 XXXX
STB (29) 1102 XXXX
```

Words 9000 through 9047 are stored in locations 1102 through 1149. The ring is left at 9048. Assume these two instructions are followed by

```
STB (29) 1200 XXXX
```

Words 9048 through 9059 are stored in locations 1200 through 1211. The timing ring is left at 9000.

Miscellaneous

These codes are used primarily for operations when the end of a reel of tape is sensed or when automatic tape-checking indicates an error. For explanations of an end-of-file or a tape-check situation, refer to those sections of the manual.

55, Rewind. Rewind the tape indicated by the data address.

56, Write Tape Mark. Write a tape mark on the tape unit specified by the data address. This tape mark is normally written after the last record has been placed on the tape. When this tape is processed for input, the tape mark turns on the end-of-file indicator.

57, Backspace (BSP). Backspace the tape specified by the data address one record.

Automatic Tape Checking

As tapes are read into the Type 650 or as output tapes are written, automatic checking is provided to insure the validity of the information. Though this checking itself requires no special programming, the corrective measures necessary are handled by programming or manual intervention. This automatic checking is described briefly in the following paragraphs.

On a writing operation, the impulses sent to the recording unit for each character are analyzed for an even bit count which represents a valid character. As all the characters in a record are written, an even-odd count of the bits sent to each of the seven tape channels is taken. One extra character is then recorded at the end of the record. The nature of this bit-count character is to provide an even number of bits in each channel of the record.

When this tape is read, each character is again checked for an even bit count. As all characters in the record are read, a bit count in each of the seven tape channels is performed. Thus, each character of a tape record is checked for even bit validity, and each tape channel is checked for an even bit count.

Tape checking and end-of-file conditions are recognized and signalled by operation code 25 BNTS (Branch No Tape Signal) and 54 BRNEF (Branch No End of File). Individual applications will determine the exact programming to utilize these OP codes for corrective measures.

25, Branch No Tape Signal (BNTS). A tape signal is considered to be either a tape end-of-file condition, a tape error in character validity, or tape channel even-bit count. Operation code 25 interrogates this tape signal and selects the I-address as the next instruction if the end-of-file indicator is turned on, or if a tape error has been detected. If neither of these tape signals has been recognized, the program branches to the D-address for the next instruction. Thus, the normal routine is programmed from the D-address; the end-of-file and tape error routines from the I-address. Figure 3 illustrates a use of the BNTS and BNEOF operation codes.

End of File

To facilitate the use of tapes, automatic procedures are set up to handle tapes when the end of either an input or output tape is reached. These procedures allow changing from one tape to another to be performed in the most efficient manner.

To signal the end of an output tape, a reflective spot is manually placed at the physical end of the tape either by the supplier or by the user. This reflective spot indicates approximately the area of the tape where the last record should be written. Sensed by a photo-electric unit on the tape unit, this spot turns on an input-output indicator. Programming in the Type 650 is then used to interrogate this indicator. The off-on condition of this indicator permits the program to utilize an end-of-file routine if necessary.

54, Branch No End-of-File (BRNEF). When an end-of-file condition is indicated by the reflective spot during a write operation or by a tape mark during a read operation, an end-of-file indicator is turned on. The last tape unit selected for reading or writing is interrogated by the BRNEF instruction. By means of the branch, the program selects the routine appropriate to the particular condition. The BRNEF instruction always turns off the end-of-file indicator and interrogates the tape error control. If a tape error is indicated, the location of the next instruction is specified by the data address. If no tape error is recognized, the location of the next instruction is specified by the instruction address. Thus, the end-of-file routine stems from the I-address of the operation code 54 instruction; the tape error correction routine stems from the D-address.

Location of Instruction	Instruction OP	Data	Instr.	Operation Abbrev.	8003 Upper Accumulator	8002 Lower Accumulator	8001 Distributor	Remarks
0019	27	9000	0020	SET				SET BUFFER AT 9000
0020	07	8012	0021	WTA				WRITE AN ALPHANUMERICAL RECORD ON TAPE 8012
0021	25	0025	1829	BNTS				BRANCH TO NORMAL ROUTINE IF NO EOF & NO TAPE ERROR
0025								NORMAL ROUTINE
1829	54	TAPE ERROR	1830	BRNEF				DETERMINE IF TAPE SIGNAL IS EOF OR TAPE ERROR
1830	56	8012	1840	WTM				WRITE THE TAPE MARK
1840	55	8012	1900	RWD				REWIND TAPE 8012
1900	66	1803	1907	RSL		+00 0000 1 0000	-00 0000 1 0000	SUBTRACT C_1 IN ACCUM. (THIS CHANGES SIGN OF C_1)
1907	20	1803	1908	STL			+00 0000 1 0000	STORE C_1 WITH SIGN CHANGED
1908	15	0020	1925	AL		0 7 8 0 1 3 00 2 1	0 7 8 0 1 2 0 0 2 1	ADD INSTRUCTION FROM 0020 TO C_1
1925	20	0020	1923	STL			0 7 8 0 1 3 00 2 1	STORE REVISED INSTRUCTION
1923	69	1830	1901	LD		0 7 8 0 1 3 0 0 2 1	5 6 8 0 1 2 1 8 4 0	LOAD DIST. WITH INSTRUCTION FROM 1830
1901	22	1830	1933	STDA			5 6 8 0 1 3 1 8 4 0	STORE INSTRUCTION WITH MODIFIED D ADDRESS
1933	69	1840	1902	LD		0 7 8 0 1 3 0 0 2 1	5 5 8 0 1 2 1 9 0 0	LOAD DIST. WITH INSTRUCTION FROM 1840
1902	22	1840	0025	STDA			5 5 8 0 1 3 1 9 0 0	STORE INSTRUCTION WITH MODIFIED D ADDRESS
								RETURN TO PREVIOUS ROUTINE
								C_1 — 00 0001 0000 LOCATION 1803

FIGURE 3. END-OF-FILE ROUTINE FOR TWO OUTPUT TAPES

End-of-File Routine. The end-of-file routine for an output tape consists of writing a tape mark and automatically rewinding the tape. (The tape mark is used for end-of-file detection when the tape is used for input.) Following the rewind instruction, the end-of-file routine may take different forms depending upon the number of tape units used for output. When only one tape unit is used, the program is normally written to stop the Type 650, allowing the operator to change tapes and then restart the machine.

If more than one tape unit is used, the end-of-file routine is normally written to alter the address of the output tapes in the program and allow the program to continue processing data, writing the output on a second or alternate tape unit. The operator may then change the tape in the first tape unit in the conventional manner without stopping the Type 650. This results in a maximum usage of machine time.

The end-of-file routine for input tapes is handled in the same manner as for output tapes. With one tape unit in use, the machine is stopped to change tapes. With two units in use, the addresses in the program are altered to permit processing to continue on a second tape unit while the operator changes the first. The only difference is in what denotes an end-of-file condition. Because the reflective spot indicates approximately when the physical end of the tape was reached, it is not exact enough to indicate when the last record on the tape has been read. It is for this purpose that a tape mark is recorded after the last actual tape record. When read, this tape mark turns on the input-output indicator. The instructions then select the end-of-file routine for the input tape. Because a tape mark is already present on the input tape, it is not necessary to write another before rewinding.

The following program (Figure 3) illustrates an end-of-file routine using two output tape units and altering the tape addresses in the program. It is assumed in this example that each tape record written is 60 words.

TAPE SORTING

A NUMBER of tape-sorting techniques are briefly described in this section. In any sorting technique it is desirable to construct the largest "block of sequences" possible on the initial split or first pass. In order to achieve this desired result, a knowledge of the numbers to be sorted is necessary. This section describes several sorting techniques that, with the knowledge of the numbers to be sorted, will help to produce a good initial split.

The following methods can be used where one item record equals a tape record or where several item records equal a tape record. If several item records equal a tape record, separating the group records during the initial split, sorting the individual item records and then regrouping them as a final operation appears to be the best procedure. The first three methods apply where one item record equals a tape record. The fourth method describes grouped record sorting.

Two-Tape Merge

This method of tape sorting can be divided into two phases of operation:

1. An initial pass in which the original file is processed and written on two output tapes.
2. All succeeding runs in which the two output tapes from the previous run serve as input and are merged to write on two other output tapes. This second phase continues until all the records are in a continuing sequence on one tape.

Regardless of the phase of operation, the processing being performed in the Type 650 is esssentially the same. This processing consists of comparing two new records with each other and with the last record written out. If, as a result of these comparisons, one of the new records is found to be in the proper sequence (ascending sequence) it is written on the same output tape as the last record. Another new record is then brought in and the comparisons are again made to determine whether either of these records may be written on the same tape.

If the comparisons indicate that neither of these records may be written on the same tape as the last record written (neither is a record of ascending sequence), the lower of these two records is written on the second output tape. A new record is then read, and the comparisons are again made to determine whether either of these records may be written on this second output tape.

This is repeated until neither record can be placed in sequence on the same tape, and the output is then switched back to tape 1. The entire initial file is processed in this manner, alternating the two output tapes. This is illustrated by the following sequence of records.

Initial Tape	*Output Tape 1*	*Output Tape 2*
17	17	3
37	37	5
5	15	6
3		24
24		29
6		31
29		
15		
31		

The two output tapes from the initial pass are then merged by the same processing arrangement as was used on the initial pass, creating two new output tapes. This is illustrated below:

Input		*Output*	
Tape 1	*Tape 2*	*Tape 3*	*Tape 4*
17	3	3	15
37	5	5	
15	6	6	
	24	17	
	29	24	
	31	29	
		31	
		37	

Tapes 3 and 4 are then used as input to write the final sequence on Tape 1.

Input		*Output*	
Tape 3	*Tape 4*	*Tape 1*	*Tape 2*
3	15	3	
5		5	
6		6	
17		15	
24		17	
29		24	
31		29	
37		31	
		37	

MODIFIED BLOCK SORT

THIS SYSTEM of tape sorting uses an input tape, two output tapes, and a miscellaneous storage area on the drum.

An initial tape is split into two output tapes. These tapes are written as long as indexes can be found equal to or greater than those of records previously written. If an index shows a drop in sequence with respect to both tapes, it is written in "miscellaneous sequence" storage on the drum. This miscellaneous sequence can hold 180 unit records. As soon as the 181st record is to be stored, an unload miscellaneous storage routine is set up.

Example A shows the initial sequence on the input tape and resultant split to the two output tapes and miscellaneous storage. Note that Tape A records are in sequence, Tape B is in sequence, but miscellaneous storage is not in sequence.

EXAMPLE A

Initial Tape	*Output Tape A*	*Output Tape B*
56	56	9
9	81	17
17	99	65
81		
2		
13		
99		
65		
41		
22		
18		
3		
.		
.		
.		

Miscellaneous Storage on Drum: 2, 13, 41, 22, 18, 3 . .

The "unload miscellaneous storage" routine writes the 181st record on Tape A. It then proceeds to work from right to left (starting at miscellaneous location 180) and writes records on Tape A as long as indexes equal to or greater than the last written on A can be found in the miscellaneous storage area. As a record is removed from miscellaneous storage and written on Tape A, its storage location is erased to zero. All 180 records are examined in this right to left search.

When this is complete, a left-to-right search of miscellaneous storage is begun. The first remaining record is written on Tape B. As long as indexes equal or greater are found, their records are written on Tape B, and their miscellaneous storage locations are erased to zero. A record which shows a drop in sequence is not written on Tape B, but is written in the miscellaneous storage area, starting at the beginning of the 180 record locations. When all 180 locations have been examined in this left-to-right search, reading of the initial tape is resumed and the process is continued.

Example B shows the result after the unload miscellaneous storage is complete. This example shows the miscellaneous storage is now empty; in practice it may contain step-down records from left to right search.

EXAMPLE B

Output Tape A	*Output Tape B*	*Miscellaneous Storage*
56	9	Before search 2, 13, 41, 22, 18, 3
81	17	After right-to-
99	65	left search 2, 13, 00, 00, 00, 0
3	2	After left-to-
18	13	right search 0, 00, 00, 00, 00, 0
22		
41		

The entire initial tape is handled in this manner: As soon as it is completely read, the output tapes are rewound. The second pass consists of a conventional two-tape merge using two input tapes and two output tapes. Writing is continued on one tape until a drop in sequence of the index is found in reading from each of the input tapes. A switch to the other output tape is then made. This process is continued until just one output tape is written.

Sorting Tape Records on the Drum

Sorting on the drum can be accomplished by proper use of the Store Buffer and the Load Buffer commands. In the example given, a block of 40 records can be sorted on the drum. It should be noted that in this method, addresses rather than records are sorted. For simplicity of explanation, each tape record is assumed to be 10 words with the sort index being the first word of the record.

In order to sort by this method, working areas of the following nature must be set up (Figure 4):

The following constants must also be included:

1. Constant 9999999999 in location 1500
2. Zeros in locations 1550 through 1999
3. Contant LBB (08) XXXX XXXX in some drum location

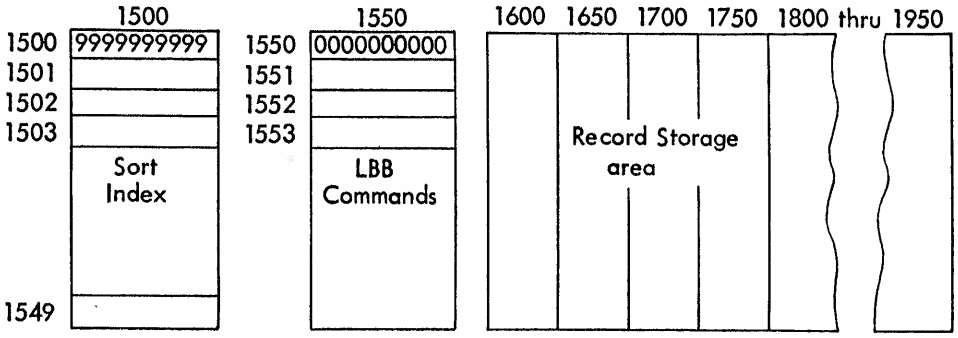


FIGURE 4. WORKING AREAS

Sorting is accomplished in this manner: The tape record is read into high-speed storage (9050-9059) and then stored in the first 10 words of the record storage area (1600-1609). Next, the sort index (in this example assume 0000003333) is placed in the distributor and in location 9000. A TLU operation is performed starting in location 1500. High-speed storage is then set at 9001 and Load Buffer command (09) is given with a data address that is the address at which the TLU operation stopped. High-speed storage now contains:

	H.S. Storage
9000	0000003333
9001	9999999999

The contents of high-speed storage are now stored back on the drum starting at the address at which the TLU operation stopped.

The data address of the constant LBB(08) XXXX XXXX is now modified by inserting the address in which the first word of the tape record is stored. LBB(08)-1600-XXXX. This modified constant is placed in location 9000. High-speed storage is now set at 9001 and Load Buffer command is given with a data address that is 50 greater than the address at which the TLU operation stopped. High-speed storage now contains:

	H.S. Storage
9000	08-1600-XXXX
9001	00-0000-0000

The contents of high-speed storage are then stored back on the drum starting at the address that is 50 greater than the address at which the TLU operation stopped.

With the storing of the LBB instruction in location (1550) the loop has been completed. The second record can now be read into high-speed storage and the loop repeated. This routine continues until 40 records have been processed. Thus, the indices for the 40 records are in band 1500: The 40 records are in the record storage work area, and their addresses are stored in band 1550. The program then refers to location 1500 which contains an LBB command whose data address is that of the first word of the first record to be written on tape. The record is written and the program goes to location 1551 which contains an LBB command whose data address is that of the first word of the second record to be written on tape. This routine will write out a block of 40 records that are in sequence.

The following charts show the contents of the 1500 band, 1550 band, and item record storage area, assuming two tape records whose sorting indices are 0000003333 and 0000000123:

	1500
1500	0000000123
1501	0000003333
1502	9999999999

	1550
1550	08-1610-XXXX
1551	08-1600-XXXX
1552	0----------0

	1600
1600	1st Record
1609	
1610	2nd Record
1619	

When a "sequence block" is completely written, a tape mark is written on the tape to indicate the end of the block. Two tape marks in succession indicate the end of file. This system tends to simplify the program required for succeeding passes.

In this procedure the first block of 40 would be written on output tape 1, the second block on output tape 2, etc.

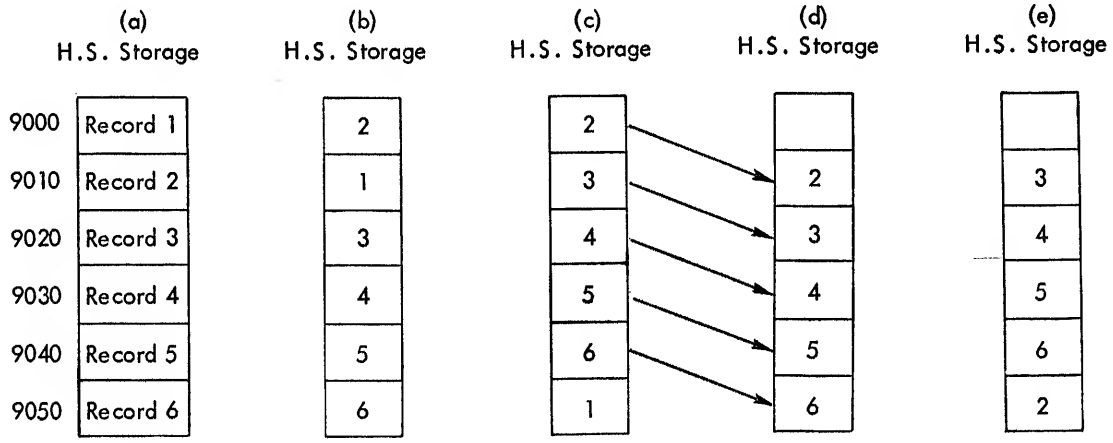


FIGURE 5. HIGH-SPEED STORAGE AFTER A READ

Sorting Grouped Records

A method of sorting grouped item records will now be described: For purpose of explanation, assume that an item record consists of 10 words and that six such item records are grouped to make up one tape record. Also assume that the sort index of each item record is the same as the position of the record and high-speed storage. (For example, the first record in the high-speed storage is called "index 1." The 3rd record is called index 3).

After a read tape command is given and a tape record is in high-speed storage, it will contain records as shown by Figure 5(a).

Subtract the second sort index from the first and interchange the item records if the first index is smaller than the second (b). Continue subtracting third from second, fourth from third, etc., until the lowest record is in the last locations of high-speed storage (c). At this time this lowest record is then written on the output tape.

Following the write command, the high-speed storage contents are rearranged (d) preparatory to finding the second lowest item record. A subtraction routine again takes place until the second lowest record is sifted to the last locations of high-speed storage (e) and written onto the ouput tape.

After each write command the high-speed storage contents are rearranged, the lowest item record sifted to the last locations and written out. This operation continues until all six item records have been written on the output tape in sequence. The charts of Figure 6 show the contents of high-speed storage before writing and after the contents have been rearranged:

It should be noted that on the output tape an item record equals a tape record.

When a "sequence block" is completely written, a tape mark is written on the tape to indicate the end of the block. Two tape marks in succession indicate the end of the file.

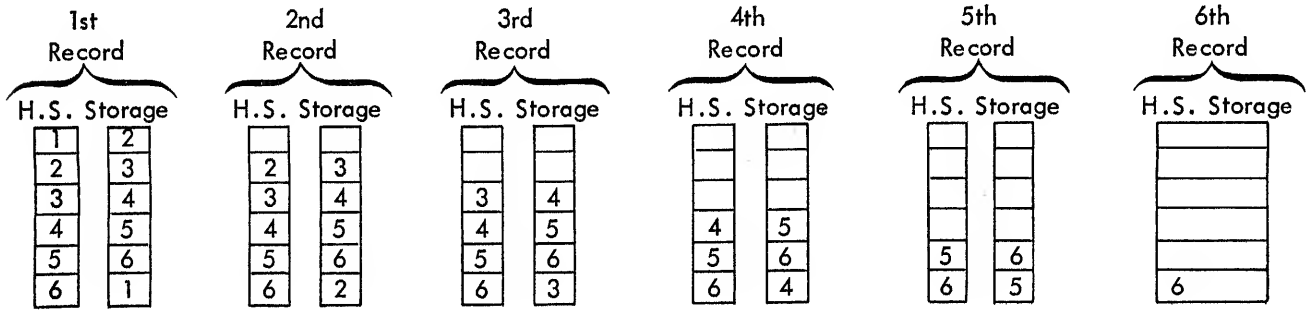


FIGURE 6. HIGH-SPEED STORAGE BEFORE WRITING

ALPHANUMERICAL DATA

Alphanumerical Data Transfer between Tape and the Type 650 System

Alphanumerical data stored on tape in the 702-705 code is stored in the Type 650 in numerical form, that is, each letter, special character, or number of an alphanumerical word is represented as a two-digit number. Thus, there are two kinds of words stored on the 650 drum:

1. Numerical words; a 10-digit numerical record.

2. Alphanumerical word; a five-character record where each character is stored as two numerical digits. Alphanumerical words carry a positive sign.

Therefore, to facilitate entry and exit of alphanumerical data, the card input and output units can be equipped with the alphabetic device and the special character device. The control panel on the input-output machine provides for specifying to the Type 650 which words are alphanumerical. Words 1-6 on the input-output machine may be equipped with the alphabetic device.

A record on tape may consist of from one to sixty words. However, when it is desired to write the alphabetic information in single-character representation, the record must be a multiple of 10 words in length; that is, 10 words, 20 words, 30 words, etc. The last word of each group of ten is the control word for the other nine. Thus, word 9009 is the control word which specifies which of words 9000 through 9008 are alphabetic. If all nine words are alphanumerical, a total of 45 alphanumerical characters, in addition to the alpha-control word, can be written from these 10 words.

The alphanumerical words of a record are identified by the digit 8 in the corresponding position of the control word. For example, an 8 in positions 2 and 4 of the control word specifies that words 2 and 4 are alphanumerical. Any digit except 8 specifies that the word is numerical. In the example above, positions 1, 3, 5, 6, 7, 8, and 9 of the control word could contain any digit other than 8 to specify that the corresponding words are numerical. Each group of 10 words within an alphanumerical record has a control word as the first word of the group when the record is on tape.

As the alphanumerical record is read from the tape into the high-speed storage unit, each control word is analyzed to control the conversion of the data from the 702-705 alphabetic tape code to the 650 alphabetic code. The alphanumerical record can then be transferred from high-speed storage to the drum for processing or for readout to the printer or punch. The record can be read out to the printer or the punch directly.

The alphabetic device and special character device for installation on the Type 407 and on the Type 533 are available in the following arrangements:

ALPHABETIC DEVICE. This device enables the input-output unit to handle mixed alphabetic and numerical words. A description of its operation is explained in *Type 650 Manual of Operation.*

SPECIAL CHARACTER DEVICE. This device is available in two groups as follows:

1. Group one consists of *11* only and *12* only codes.

2. Group two consists of 407 special character codes, including *11* and *12* codes for a total of eleven special characters.

The special character device requires no additional control panel wiring beyond that described in the *Type 650 Manual of Operation.*

Write Alphanumerical Record on Tape from a Card Input Unit

Many applications will require that alphanumerical data from cards be written on tape. Typical of these are the updating of a tape file to add new items or to make changes on an inventory tape, personnel master, policy master, program tape, etc.

The following simplified programming routine illustrates the writing of an alphanumerical record on tape from a card in the Type 533 reader. In practice, this routine would be supplemented by an end-of-file routine and be part of a larger program. Note that word 10 on the Type 533 control panel is the control word for the record. Two methods of writing this tape record are shown in Figure 7:

	1	2	3	4
Memory Address	0501	0502	0503	0504
Load Card				
Input Card	DEPT. | EMP. NO.	EMPLOYEE	NAME →	

STORAGE ENTRY WORDS					
5	6	7	8	9	10
0505	0506	0507	0508	0509	0510
JOB CODE	YTD AMOUNTS →		CURRENT PAYROLL AMTS.		ALPHA. CTRL

NUMERICAL FORM
(100 numerical digits)

LOCATION OF INSTRUCTION	OPERATION		ADDRESS		REMARKS
	ABBRV.	CODE	DATA	INSTRUCTION	
0001	RD1	70	9050	0002	READ A CARD IN THE 533
0002	SET	27	9050	0004	SET THE CORE BUFFER AT 9050
0004	WT	06	8010	—	WRITE NUMERICAL RECORD ON TAPE

SINGLE CHARACTER REPRESENTATION
(85 characters: 15 alphabetic, 60 numerical, 10 alpha-control)

LOCATION OF INSTRUCTION	OPERATION		ADDRESS		REMARKS
	ABBRV.	CODE	DATA	INSTRUCTION	
0001	RD1	70	9050	0002	READ A CARD IN 533
0002	SET	27	9050	0004	SET THE CORE BUFFER AT 9050
0004	WTA	07	8010	—	WRITE ALPHANUMERICAL RECORD ON TAPE

FIGURE 7. WRITING AN ALPHANUMERICAL RECORD ON A TAPE FROM A CARD INPUT

1. Writing it in numerical form, no alpha-control word required (word 10 on the Type 533 can then be used for other data).
2. Writing it in single-character representation where word 10 on the Type 533 is the alpha-control word. Positions 2, 3, 4, of the alpha-control word would contain 8's to identify words, 2, 3, and 4 as alphanumerical.

PRINTER

THE PRINTER for attachment to the Type 650 is a standard Type 407 Accounting Machine equipped with a special device that provides for complete interchange of data between the two machines.

Either a Model A1 or Model A2 407 can be specified. Card feeding and printing operations of the 407 are controlled by the 650. However, the 407 units, such as counters, selectors, MLR, storage units, and forms carriage, are operative. This means that 650 results can be accumulated in the 407 counters for control or summary purposes. An MLR card can read data into the calculator on the first MLR cycle and continue printing the remaining MLR information while the 650 is processing.

The 407 can be used independently of the 650 as a conventional accounting machine.

Selectors on the 407 and the control word of the 650 provide considerable flexibility for interchanging data between the accounting machine and the 650. The selectors can be controlled from card punching or control information exits. Thus, the 650 control words can be assembled on the control panel to select the program routines for that card. Also, control word data from the 650 can direct carriage operations, counters, and storage units on the accounting machine. Many applications will use the 407 as both input and output to the 650. Thus card feeding and printing may occur on the same 407 cycle to print and feed cards at a maximum rate of 150-per-minute.

Further flexibility for data processing is provided by the fact that the 407 read and print operations are under the control of the stored program of the magnetic drum.

DRUM INPUT-OUTPUT STORAGE AREAS

THREE AREAS of the drum are reserved as card input-output storage areas. These three areas are non-addressable and are comparable to the area formerly known as the 533 read and punch buffer. Each area can accommodate either a 407 or a 533 input-output machine. A total of three machines made up of 407's and 533's can be attached to the 650 at one time. For example, two 533's and a 407; or two 407's and a 533 can be attached.

Each input-output storage area is divided into two sections, one section provides a 10-word input; the other provides a 10-word output. Three operation codes are assigned to each area, and they provide the means of controlling the input-output machine connected to the area.

Figure 8 shows the angular relationship of the three input-output storage areas to the 40 bands of general storage.

OPERATION CODES

BECAUSE the three areas are identical, their corresponding operation codes perform identical functions. Operation codes 70, 71, 72 are assigned to area 1; operation codes 73, 74, 75 apply to area 2; operation codes 76, 77, 78 are assigned to area 3. In order to simplify the explanation, the 407 control is described as connected to input-output storage area 2. When the 407 is connected to either area 1 or 3, its operation is identical to the following explanation with the exception that the operation codes used are for the corresponding input-output storage area.

73 RD2 (Read into Input Storage Area 2)

This operation code causes the 407 to read a card. This is performed as a two-step process:

1. The contents of the ten words of input storage area 2 are automatically transferred to one of the 20 (or 40) possible ten-word groups of general storage. The group selected is determined by the D-address of the read instruction. The D-address determines the drum band. Word one is stored in word 39 (or 89) of the band; words 2-10 are stored in succeeding word locations 40-48 (or 90 to 98). The read instruction (Code 73) can transfer 10 words from the 407 input storage directly to high-speed storage by a D-address of 9000, 9010, 9020 . . . 9050.

2. A card is moved into the second reading station of the 407, and its information is placed on the drum in the unaddressable area called input storage area 2.

Thus the input storage section of the 650 drum always contains information from the card just read in the card feed of the 407.

75 RC2 (Read Conditional into Input Storage Area 2)

This operation code causes the 10 words in input storage area 2 to transfer to the general storage band specified by the D addresses of the instruction. It also conditions the 407 feed to read but does not by itself cause a card feed or card read operation. The card

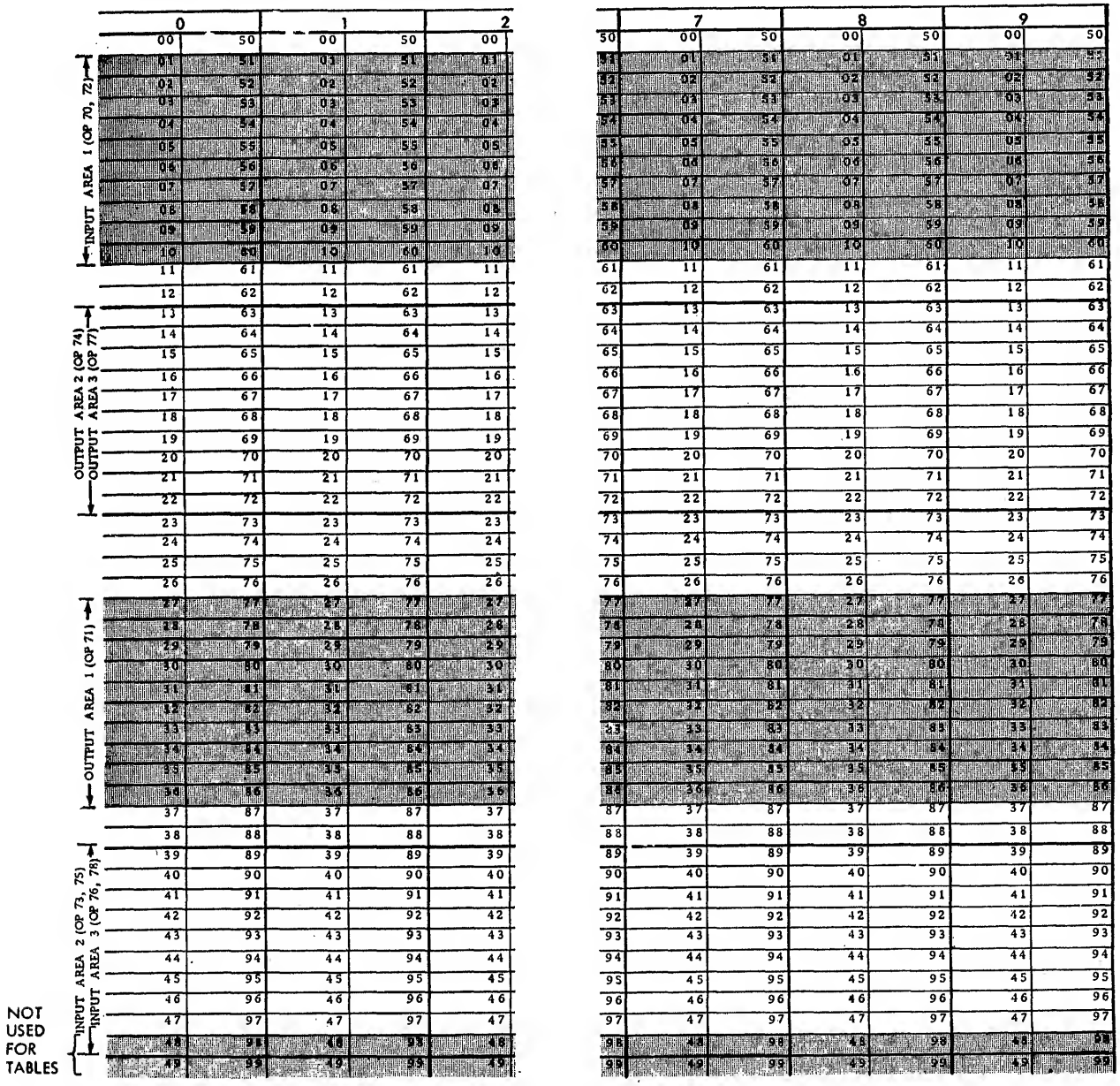


FIGURE 8. ANGULAR RELATIONSHIP OF INPUT-OUTPUT STORAGE AREAS TO GENERAL STORAGE

feed is now dependent upon a code 74 (Write) instruction following in the programming.

An example of the relationship between the 75 RC2 and 74 WR follows: The 75 code transfers data (read from a card in the 407 feed) to general storage for processing in accordance with an instruction routine. To print, an operation code 74 (Write) is called for, and the 407 then prints and reads the following card. The 407 prints because of the 74 code; it reads a card simultaneously because a code 75 (RC2) preceded the 74 code. Thus, the 75 code must subsequently be followed by a 74 code in the program to complete the second phase of the read operation. An error would be signalled if either a 73 RD2 or a 75 RC2 code followed a 75 RC2 code in the program unless a 74 WR2 code intervened between the two read codes. This error is a validity check which is recognized when the transferred data is referred to by programming.

74 WR2 (Write from Output Storage Area 2)

This operation code causes the 407 to take a print cycle and allows the 650 output hubs on the 407 con-

INSTR NO.	LOCATION OF INSTRUCTION	OPERATION		ADDRESS		REMARKS
		ABBRV.	CODE	DATA	INSTRUCTION	
	0122	SET	27	9050	0125	SET CORE BUFFER
	0125	RT	04	8010	0126	READ A TAPE RECORD
	0126	WR2	74	9050	—	PRINT

FIGURE 9. PRINT A RECORD READ FROM TAPE

trol panel to emit. The 407 will print and read a card on the same cycle if the 74 code is preceded by a 75 RC2 code in the programming as previously explained. The D-address of the print instruction can be a drum or high-speed storage address.

Programming Example — Tape to Printer

The following programming (Figure 9) shows the transferring of a record from tape to printer. The record can be of either numerical, or mixed alphabetic and numerical data. The alphabetic data are on tape in two-digit representation and would be converted to single character by the alphabet device on the 407.

FLOW OF INPUT-OUTPUT BETWEEN TYPES 407 AND 650

THE MAXIMUM rate of read-print operation of the 407 is 150 per minute. However, this may vary on specific applications where the 650 processing is of considerable length or where other units, such as tapes and the 533, are consulted. Programming routines should be arranged to process drum or high-speed storage data during the time that an input-output unit is recording the previous result.

Figure 11 is a schematic showing the 407 to 650 relationship with reference to a 407 machine cycle. No attempt is made to indicate the amount of 650 processing that may occur between 407 cycles. Individual applications will determine whether printing is to occur occasionally, or on each 407 cycle.

On the initial run-in, the first card in the 407 feed is read at second reading and its data placed in the input storage area on the drum. Succeeding card feeds and print operations must be called for by the stored program. Figure 11 shows that Type 650 results return to the 407 two cycles after the data were read by the 407. This implies that on a detail print operation, results from the 650 would print two lines below data printed directly from the card when it was at second reading. However, this condition can be minimized because all information to be printed may be transferred through the 650 to appear on the printed form on the same line. Or the storage units and counters of the 407 can be set up to store alphabetical or numerical information for delayed printing on a cycled basis.

The schematic also shows that a 73 RD2 operation code is used initially and succeeding read operations are called for by the 75 (RC2) code. Thus the 407 feed is one card ahead of 650 processing, which permits maximum operating speed of the accounting machine. The operation code 75 (RC2) could have been used instead of the 73 code for programming the initial read.

Figure 10 shows the programming for 407 input-output control illustrated by the Figure 11.

INSTR NO.	LOCATION OF INSTRUCTION	OPERATION		ADDRESS		REMARKS
		ABBRV.	CODE	DATA	INSTRUCTION	
		START		ROUTINE		
	0000	RD2	73	0139	0001	READ FIRST RECORD
	0001	PROCESS DATA AND STORE FOR PRINT ROUTINE				MAIN ROUTINE
	0100					
		NORMAL	407	CONTROL	ROUTINE	
	0101	RC2	75	0139	0102	TRANSFER DATA FROM NEXT CARD INTO GEN. STORAGE
	0102	WR2	74	0113	0001	PRINT RESULTS OF PROCESSING - READ NEXT CARD

FIGURE 10. PROGRAMMING FOR INPUT-OUTPUT CONTROL OF THE 407

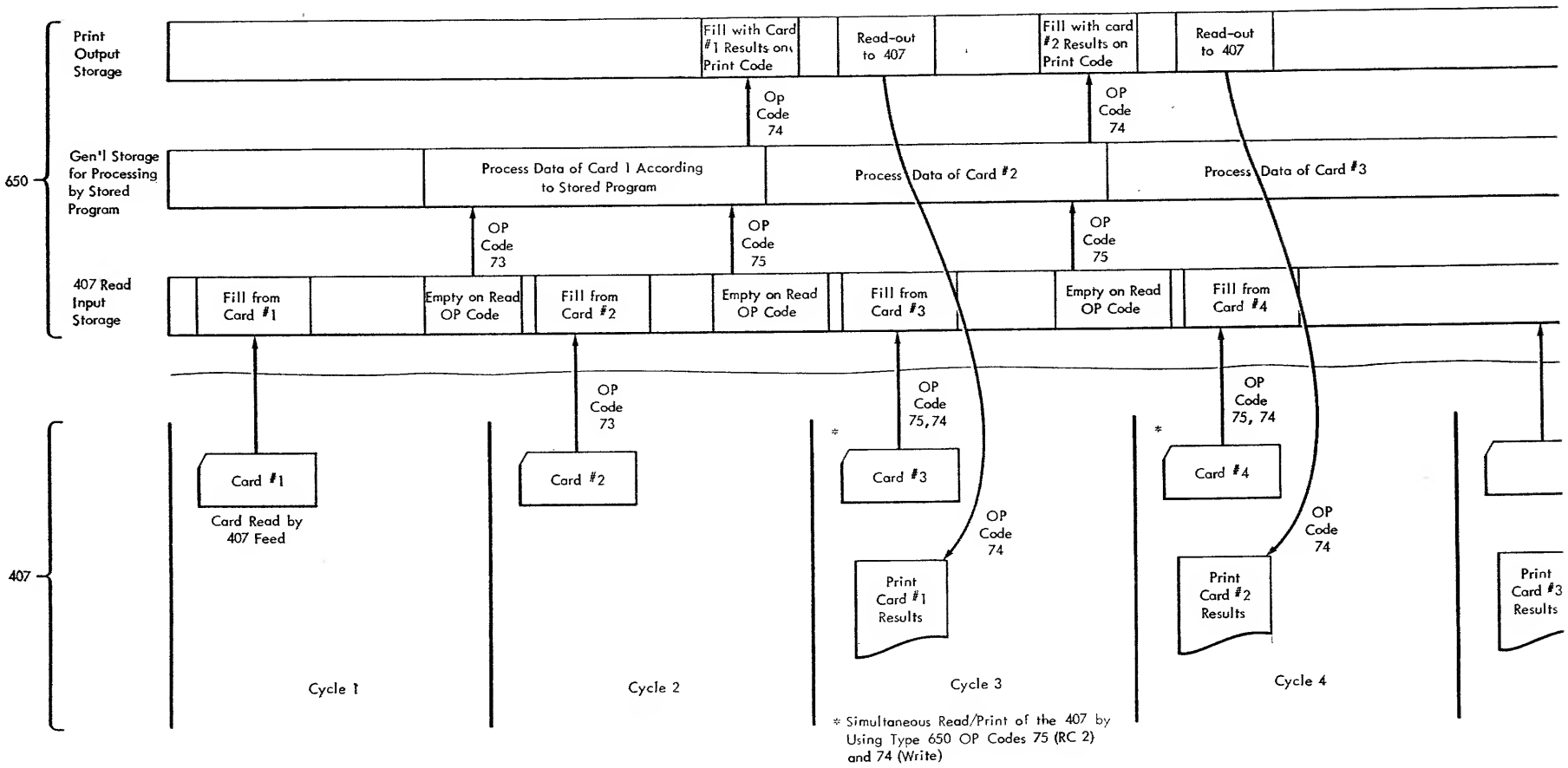


FIGURE 11. SCHEMATIC OF 407 INPUT-OUTPUT RELATIONSHIP TO 650 OPERATION

TYPE 407 CONTROL PANEL

THE FLEXIBILITY of the 407 as an input-output device for the 650 is provided by additional hubs on the 407 control panel.

These provide input and output paths between the 650 and the 407 for numerical, alphabetic, special character, and control information.

Capacity is provided for the transfer of 10 words between the two machines. Many of these additional 407 hubs have labels that are identical to hubs on the 533 control panel. This is because they perform the same function on input and output as the corresponding 533 read-punch machine hubs.

Figure 12 shows that the 650 hubs are located in 4 areas of the 407 control panel as follows:

1.	AM-AN, 1-40	Storage entry (Words 1-8)
2.	AX-AY, 1-40	Storage exit (Words 1-8)
3.	S-AO, 75-80	Controls and alphabet device
4.	AO-AV, 43-52	Storage entry and exit—Words 9-10 and sign hubs
5.	A-M, 47-52	Pilot selector hold and bus hubs

Note that areas 1, 2, 3, and 5 are in the same location as counters 6H-8K and digit selectors 4-6 on a full-capacity Type 407 Accounting Machine. Thus these counter groups and digit selectors are not available on a 407 attached to the 650.

Storage Entry, Words 1-10 (AM-AN; 1-40) (AO-AP; 43-52). Each storage entry word has capacity for ten positions of numerical information. They are active on the card cycle that results from a read operation in the 650 program and are normally wired from second reading.

The units position of each storage word will accept digit impulses (9-12). The 12 and 11 impulses in this position are used for sign identification under the control of the read sign units (RSU) and read plus (R+) switches. When the 650 alphabetic device is installed on the 407 these hubs accept alphabetical information as described in the alphabet device write-up.

Sign Entry (AQ; 43-52). These ten hubs are the sign entry hubs for the ten words of storage entry and are active when the RSU switch is not wired. Each hub is associated with its respective word of storage entry. They accept an 11 impulse for minus amounts; and if the R+ switch is wired, they also accept a 12 impulse for positive amounts.

Storage Exit, Words 1-10 (AX-AY; 1-40) (AS-AT; 43-52). Each storage exit word is an exit for ten positions of information from the 650. They emit under control of operation codes 71, 74, 77 (Write) from the 650.

Sign Print Exit (AU; 43-52). These ten hubs are the sign exit hubs for their respective words (1-10). When a negative amount is read out from STORAGE EXIT, the SIGN PRINT EXIT will emit an 11 impulse. This 11 impulse prints a minus character when wired to PRINT ENTRY. When the PRINT PLUS (P+) hubs are connected, SIGN PRINT EXIT will emit a 12 impulse for positive amounts.

Sign Control Exit (AV; 43-52). There are ten sign control exit hubs, one for each word. When a minus amount is read out of a storage exit word, the SIGN CONTROL EXIT hub for the corresponding word emits an impulse. The early timing of this impulse permits it to be wired to the immediate pickup of pilot selectors and co-selectors. The selector is then transferred in sufficient time for the selection of card cycles, all cycles and print cycles impulses on the cycle in which the negative amount is read out of STORAGE EXIT words. The sign control exit impulse timing and duration are such that they cannot be wired directly to transfer print, progressive selector cpl, or non-print.

Control Information (S-AB; 75). The control information feature consists of ten hubs (1-10). Each hub corresponds to a position of control word 10: Hub 1 refers to the units position, hub 10 to the high-order positions of word 10. Control information hubs emit when their corresponding word 10 positions contain a digit 8 on a print (Operation Code 77) operation. Control information hubs are normally wired to the immediate pickup of pilot selectors and co-selectors. Because of the early timing of the control information impulse, the selector is transferred in sufficient time for the selection of card cycles, all cycles, and print cycles impulses on the 407 panel.

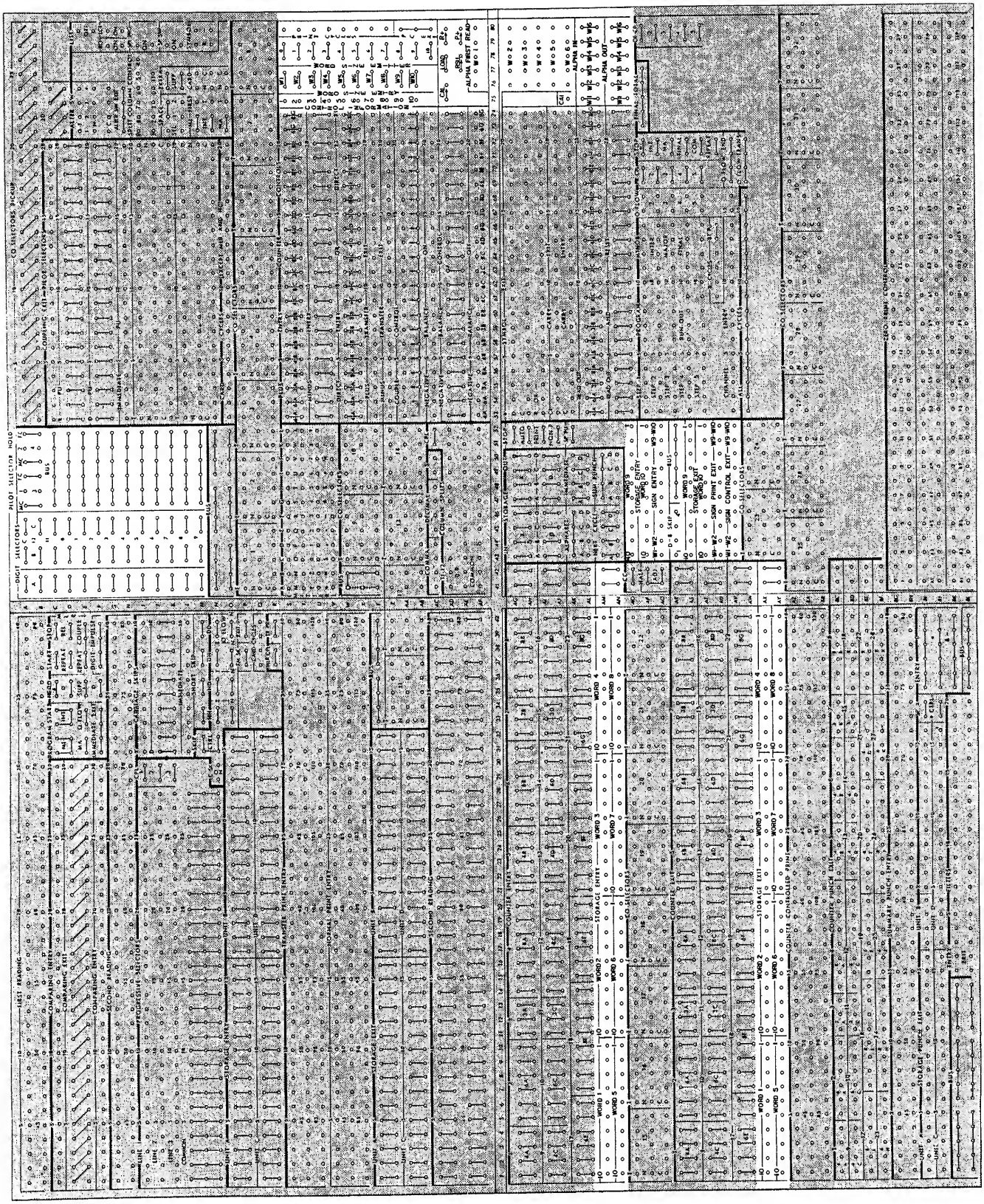


FIGURE 12. TYPE 407 CONTROL PANEL DIAGRAM

Word-size Emitter (S-AC; 78-79). These hubs, labeled zero through ten (0-10) are used to fill in zeros automatically to the left of the most significant digit of storage-entry words. It is necessary to enter these zeros in order to satisfy validity checking conditions.

Each of these hubs is labeled to correspond to the number of digits actually being entered into a storage-entry word. For example, a WORD-SIZE EMITTER hub 7 will put zeros into the three high-order positions of a word; WORD-SIZE EMITTER hub 4 will put zeros into the six high-order positions of a word, etc.

When all ten positions of a storage-entry word contain a digit, WORD-SIZE EMITTER hub 10 must be used. WORD-SIZE EMITTER hub 0 can be used when it is desirable to put all zeros in a storage-entry word.

It is possible to select the word-size emitter impulse by using a pilot selector or co-selector. Word size emitter must be wired to WORD SIZE ENTRY only and not to any other 407 function.

Word Size Entry (S-AB; 76-77). These hubs perform a function identical to that of word size entry on the Type 533 Read Punch Unit. They accept an impulse from the word size emitter to fill in high-order zeros in storage entry words.

Cal (Calculate Switch) (AD; 75-76). This switch must be jackplugged whenever the 407 is used as an input or output device of the 650. When this switch is disconnected, any 407 feature that has been modified for 650 operation reverts back to normal 407 Accounting Machine Operation.

Load (AD; 77-78). The load hub accepts a 12 impulse from first reading to identify that card as a load card. It is used in loading operations in the same manner as the corresponding load hub on the Type 533 control panel. All 80 columns of that card will be automatically loaded from second reading into storage entry. On the cycle in which a load card is being read, the second reading hubs on the 407 panel are active and thus can be used to detail print or accumulate data from the load card.

RSU (Read Sign over Units) (AE; 77-78). When this switch is wired, the units position of each storage entry word is conditioned to accept the sign identification as well as the units digit of the factor being entered. This switch is independent of the R+ (Read Plus) switch.

R+ (Read Plus) (AD; 79-80). The read plus switch is wired to identify positive amounts with a 12 punch. It conditions the sign entry hubs (or the units position of each word if RSU is also wired) to accept the positive sign indication. When this switch is wired, a 12 impulse must be used to identify each positive word.

P+ (Print Plus) (AE; 79-80). When the PRINT PLUS switch is wired, a 12 impulse is emitted from SIGN PRINT EXIT for positive factors which may be wired to print entry to identify these positive amounts.

Print Cycles (S-Z; 80). These eight hubs emit on a print cycle initiated from a Type 650 operation code. The impulse emitted is similar to an all cycles impulse.

PC-EX (Print Cycles Exit) (AA-AC; 80). These three common hubs emit on a print cycle caused by a Type 650 operation code Write. The impulse emitted is similar to a control information, or sign control exit impulse.

D-8-Skip (Digit 8 Skip) (AR; 43-46). The D-8-Skip hubs are entry hubs to control forms skipping. They accept a digit 8 impulse, which can be wired from Type 650 storage exit positions or the character emitter. Four hubs are provided to initiate skipping to carriage tape channels 1-4 respectively. The standard Type 407 carriage skip hubs X, D for channels 1-4 have been altered to accept impulses on any active machine cycle. Channels 5-10 accept impulses only on card feed cycles, which is the standard Type 407 operation.

BUS (AR; 47-52 and *C-M; 47-52).* Bus hubs are located in these two areas. Note that Digit Selectors 4-6 cannot be installed on a Type 650-407 as this area is reserved for bus hubs.

Alphabetic Device (AF-AO; 75-80; Special Device). These special device hubs perform the same function on the 407 as the corresponding alphabet device hubs on the 533 read punch panel.

Alpha First Read (AF-AK; 76-80; Special Device) Accepts the 5-position alphabetic word from first reading and analyzes each position to determine whether it contains a number, letter, or special character.

CAI *(AK; 75; Special Device).* This hub emits a constant alphabetic impulse which is wired to ALPHA IN or ALPHA OUT. CAI emits on all cycles except load card cycles.

Alpha In (AL-AM; 75-80; Special Device). ALPHA IN are entry hubs for words 1-6, which set up the corresponding storage-entry word to receive alphabetic information. They accept impulses from hubs such as CAI or pilot selector couple exit.

Alpha Out (AN-AO; 75-80; Special Device). ALPHA OUT are entry hubs for words 1-6, which allow the conversion of the corresponding storage exit word to alphabetic characters. ALPHA OUT can be impulsed by hubs such as CAI, control information, sign control exit, PC-EX and pilot selector couple exit.

MODIFICATIONS TO STANDARD TYPE 407 CONTROL PANEL HUBS

WHEN THE 407 is used independently of the 650, all the control-panel features operate as standard 407 features. When the Type 407 is used with the 650, the Cal (calculate) switch is jackplugged and several control panel features operate differently from conventional 407 operation. These changes make the 407 a more flexible input-output device and are as follows:

Multi-Line Read Operation

An MLR operation can be initiated by a card in the 407 feed during a 650-407 program. Card movement in the 407 feed is under control of 650 Read OP codes. Therefore, in an MLR operation, the 650 storage entry and exit hubs are active only on MLR line 1. Succeeding MLR cycles continue to occur independently of the Type 650 program. MLR operation is stopped by conventional 407 control-panel wiring. Because Type 650 programming continues while the second and succeeding MLR cycles occur, an operation code Write may be recognized. In this case the 650 program will be interlocked to wait until 407 MLR printing is complete. The 650 controlled print cycle will occur following the MLR cycles. When the 650 programming is such that OP codes referring to the 407 do not occur during MLR cycles, the 650 is not interlocked and programming continues in a normal manner.

Pilot Selectors

Standard Type 407 pilot selector operation is as follows: The X and D hubs accept an impulse on a machine cycle (card cycle or program cycle), the selector transfers on the following machine cycle and remains transferred until the next card feed cycle.

The 650-407 has control panel switches that allow the pilot selectors to return to a normal status at the end of the *following machine cycle* instead of remaining transferred until the next card cycle. Each switch places five pilot selectors on either a machine cycle hold or a card feed cycle hold basis.

Pilot Selector Hold Switches (A-B; 47-52). Four switch locations are provided. Each switch controls a group of 5 pilot selectors. Switch 1 controls pilot selectors 1-5. Switch 2 controls pilot selectors 6-10, etc. Each switch consists of 3 hubs labeled MC, 1, FC. The MC refers to machine cycles; FC refers to card feed. The center hub 1, 2, 3, or 4, refers to the pilot selector group. Thus by placing a jackplug in MC to 1, pilot selectors 1-5 operate as machine cycles pilot selectors. By jackplugging FC to 1, the pilot selector group drops out under card feed control.

Program Start — Minor, Intermediate, Major

The program start hubs accept an impulse to begin program cycles. Standard 407 operation allows these hubs to accept only on card cycles. Type 650-407 operation provides that these hubs accept digits 9-12 on any active machine cycle. For example: On a print cycle initiated by a 650 Op Code Write, an impulse directed to the minor program start causes a minor program cycle to follow the 650 controlled print cycle.

When other than a minor program cycle is initiated, such as a major or special program operation, all the program cycles occur in sequence, following the 650 controlled print cycle. 650 Programming is interlocked for only a portion of the 650 controlled print cycle and will be in progress during the 407 program cycles. If the 650 programming encounters a 407 operation code while the 407 program cycles are occurring, the 650 is interlocked to wait until the 407 program cycles are completed.

Forms Control

All of the flexibility of conventional 407 spacing and skipping are retained. Skipping can be initiated by 650 control word information to occur immediately, or after printing. Skipping immediately is a short skip of not more than 2 inches, and the short skip hubs must be wired.

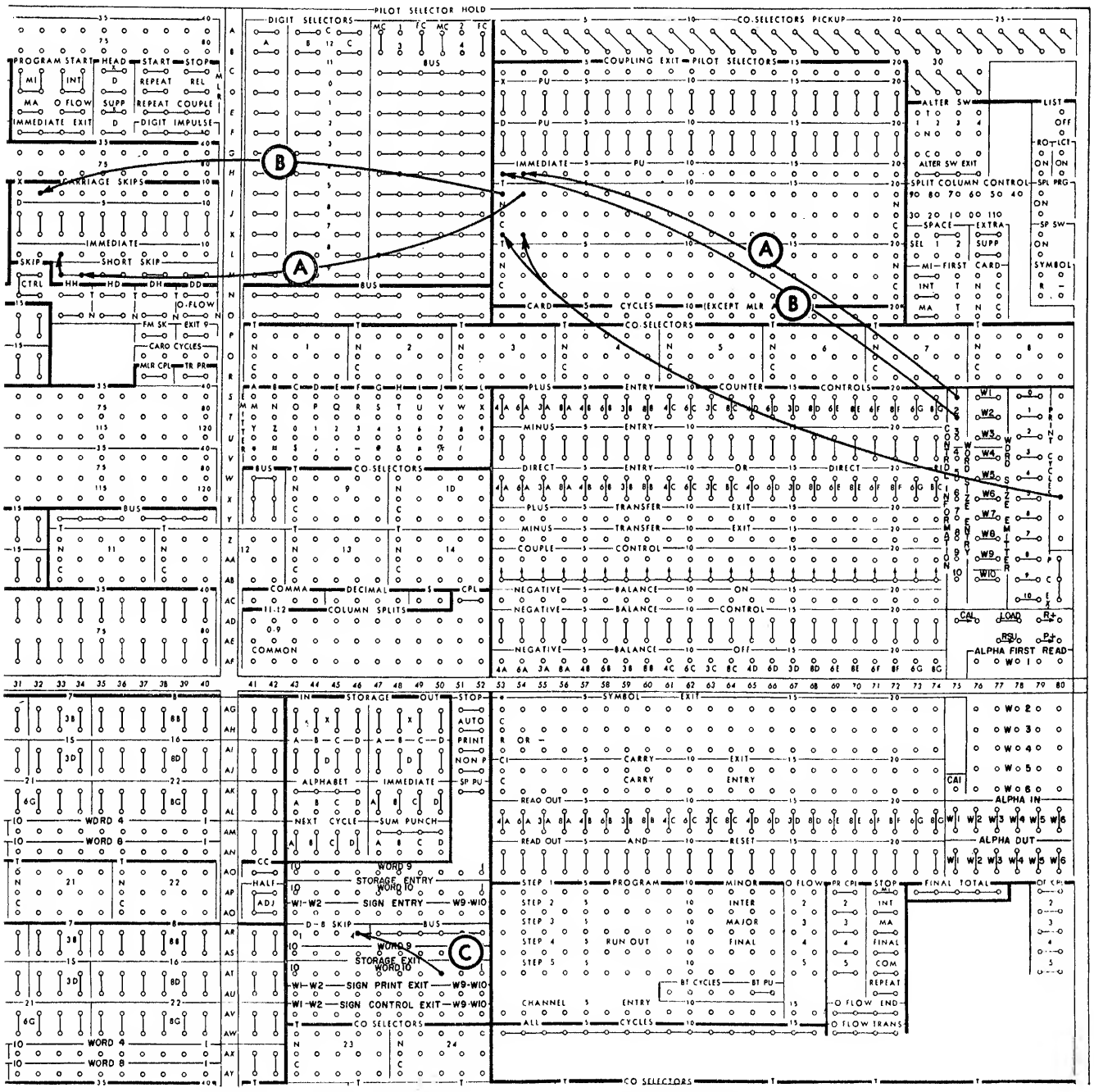


FIGURE 13. THREE METHODS OF CONTROL PANEL WIRING FOR SKIPPING

Type 650-407 operation modifies the carriage skip X and D hubs for channels 1-4 so that these hubs accept impulses on any active machine cycle (either card cycle or print cycle). In addition, 4 hubs (8 Skip, Channels 1-4) have been added to the control panel, which accept a digit 8 impulse to initiate skipping. These have been previously explained in the control-panel description section.

Thus forms skipping, under 650 control, can be handled in three ways. This is shown on Figure 13.

1. Wiring A shows a short skip to channel 3, which occurs before the data from the 650 exits are printed.

2. Wiring B shows a skip to channel 2 initiated by control information 1. The skip occurs after the 650 data is printed.

3. Wiring C causes a skip to channel 4 whenever a digit 8 is read out by the hundreds position of storage exit word 10.

FILE MAINTENANCE OF A TAPE RECORD

A SIMPLIFIED application is included to illustrate programming of the tape and printer features. Figure 14 shows a general block diagram.

This file maintenance operation utilizes 2 tape units, high-speed storage, the printer and only a small part of the drum. The 533 read punch unit is not needed. Therefore by parallel programming, another application using the drum capacity and 533 can be in operation simultaneously with this file maintenance operation.

The input consists of a master pricing tape and change cards. The output is a pricing tape that has been updated by the change cards, and a printed change listing. The change listing shows only those items on which there has been activity and serves as a visual record of the change. A change card can be a new item, a deletion, a description change, or a change to any one or all of the 5 prices for the item.

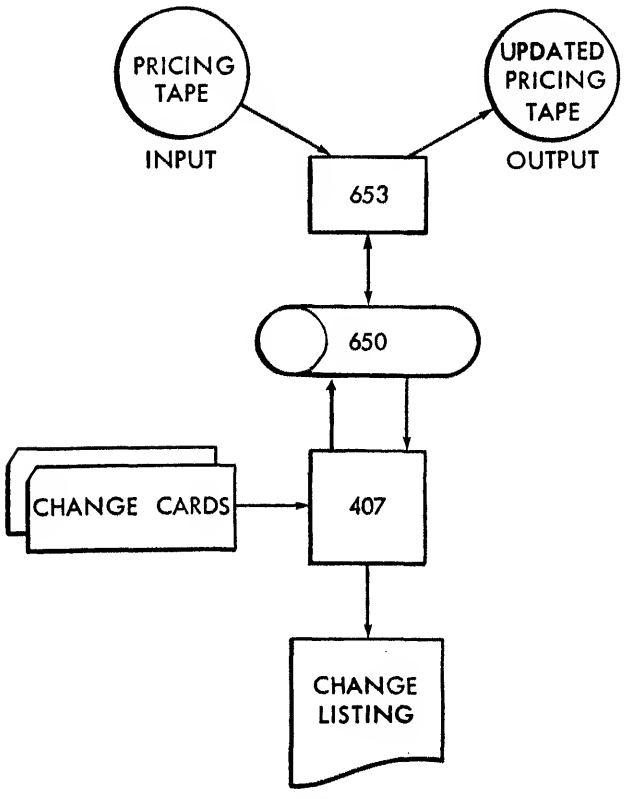


FIGURE 14. FILE MAINTENANCE — GENERAL

A type change code specifies the kind of change, and a price code specifies the prices being changed.

Record Layout

The layout for the price record on tape, card, and printer is shown in Figure 15.

The tape record consists of ten words for each item number. These have been recorded as individual tape records.

Note that each item may contain as many as five prices. Changes to any one or all five of these prices can be made by the one change card. Prices that are not to be changed are indicated by an X in the high-order position of the field.

The change code in column 21 is as follows:

Code 1 = new item
2 = delete the item
3 = description change
4 = price change

High-Speed Storage

The change card record is placed in words 9000-9009 of high-speed storage. The tape record is read into and out of words 9050-9059 of the high-speed-core buffer.

A block diagram of the file maintenance is shown by Figure 16. Because this application uses very little of the Type 650's capacity, another operation can be parallel programmed to occur simultaneously. This parallel program can be block diagrammed to be integrated with the file maintenance operation.

A portion of this block diagram has been programmed to illustrate 650 Tape-Printer operation. Figure 17 shows the programming for a new item change card. Figure 18 shows the control panel wiring for the change listing. Note the similarity of this wiring to conventional 650-533 wiring.

The 650 storage entry hubs are wired from second reading. Type 650 storage exit words are wired to normal print hubs. The alphabet special device wiring is the same as 533 alphabet device wiring.

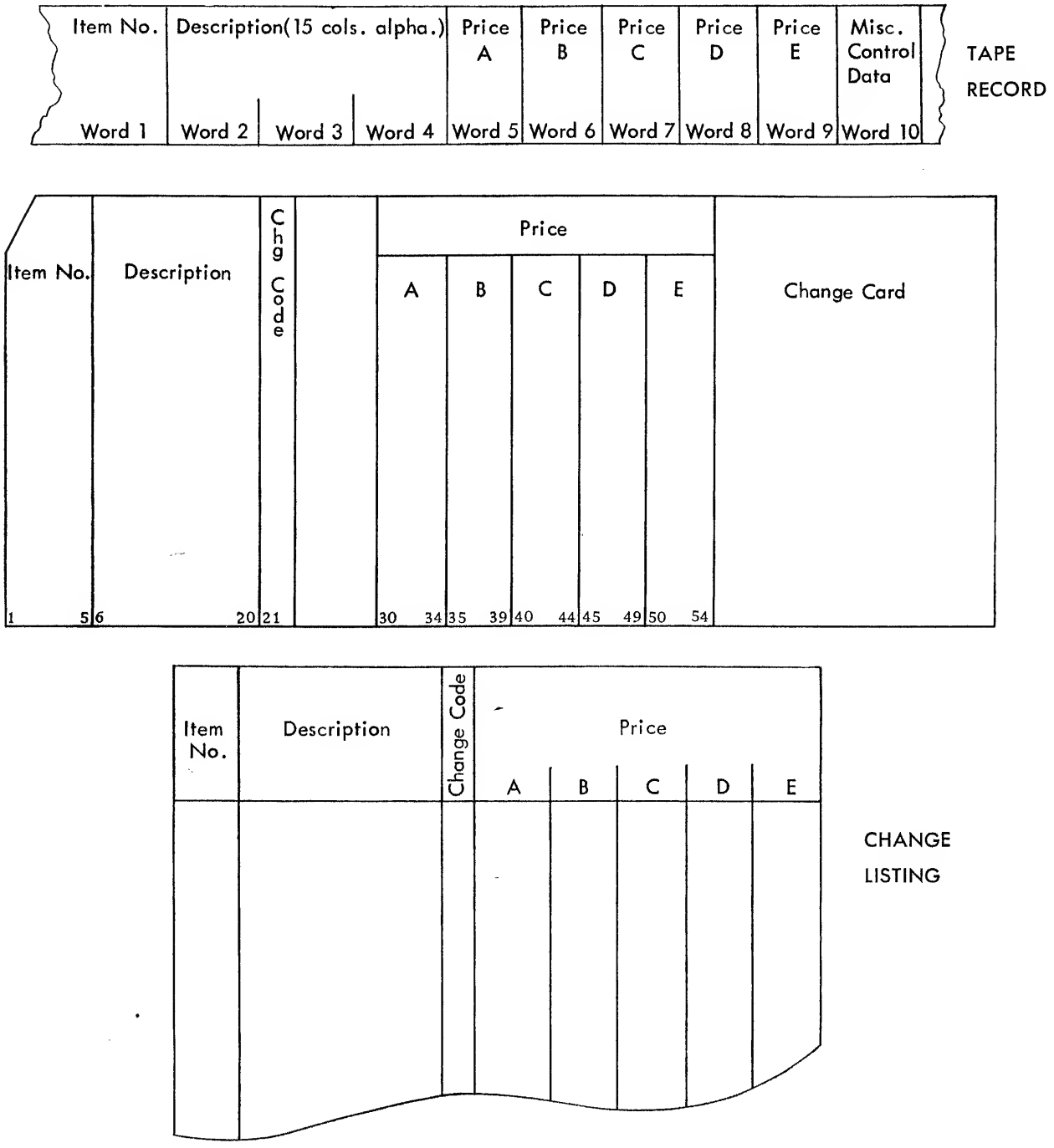


FIGURE 15. RECORD LAYOUT

Pilot selectors 1-5 are picked up from X-punches over the high-order position of the price fields. The X indicates that the price is not being changed. Therefore, the pilot selector's function is to place 9's in word 10 to indicate price fields that are not being changed. When any of the pilot selectors 1-5 are normal, an 8 will be placed in the corresponding position of word 10. Pilot selector 8 controls single or double spacing, and this is dependent on the 650 program, which places an 8 in the high-order position of the word 10 when a single space is desired.

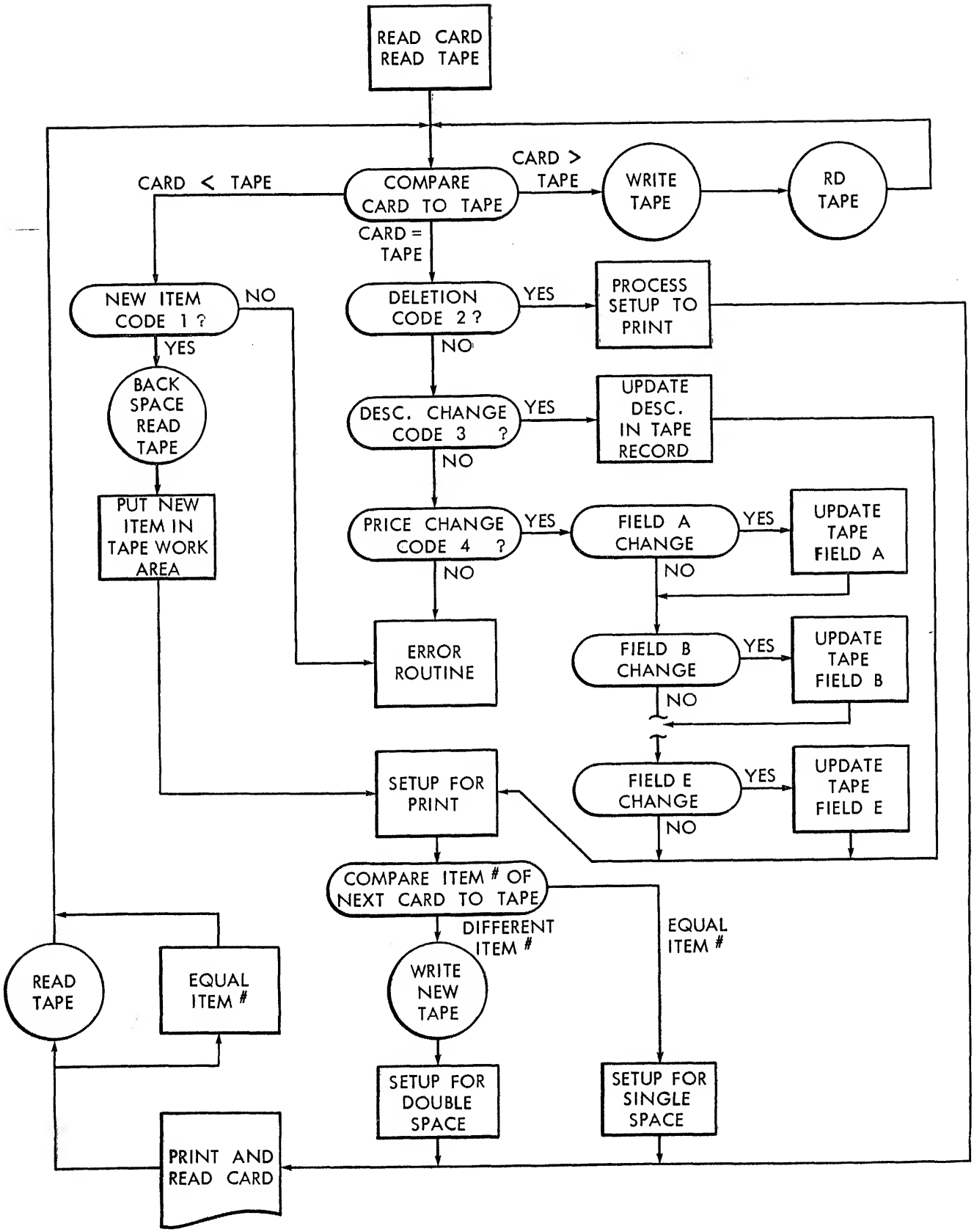


FIGURE 16. FILE MAINTENANCE BLOCK DIAGRAM

INSTR NO.	LOCATION OF INSTRUCTION	OPERATION		ADDRESS		REMARKS
		ABBRV.	CODE	DATA	INSTRUCTION	
		START ROUTINE				
	0000	RD2	73	9000	0001	Read card
	0001	SET	27	9050	0002	Set high-speed storage
	0002	RT	04	8010	0003	Read tape
		COMPARE				
	0003	RAU	60	9000	0004	
	0004	SU	11	9050	0005	
	0005	BRMIN	46	0010	0006	
	0006	BRNZU	44	card greater	card equal tape	
		NEW ITEM				
	0010	RAU	60	9009	0011	Check for new item code
	11	SRT	30	0005	12	
	12	SU	11	C1	13	
	13	BRNZ	45	error	14	
	14	BSP	57	8010	15	Backspace read tape
	15	SET	27	9000	16	
	16	STBB	28	0140	17	
	17	SET	27	9050	18	
	18	LB	09	0140	0040	
		STORE FOR PRINT				
	0040	AL	15	9059	0041	Place word 10 in accumulator for future
	41	STBB	28	0163	0051	Transfer record to drum space control
		COMPARE ITEM NUMBER				
	0051	RC2	75	9000	0052	Transfer next card data to core storage
	52	RAU	60	9000	60	
	60	SU	11	9050	68	
	68	BRNZ	45	0072	0073	
		DIFFERENT ITEM				
	0072	SET	27	9050	0076	
	76	WT	06	8011	80	
	80	AL	15	C3	85	
	85	STL	20	0172	95	Setup for double space in word 10
	95	SL	16	8002	0110	
		SAME ITEM NUMBER				
	0073	AL	15	C2	0090	Setup for single space in word 10
	90	STL	20	0172	0098	
	98	SL	16	8002	0110	Restore lower accumulator to zero
		PRINT & READ				
	0110	WR2	74	0163	0111	Print
		READ NEXT TAPE RECORD				
	0111	BRNZ	45	0112	0003	Test item number for branching
	0112	SET	27	9050	0113	
	0113	RT	04	8010	0003	
						CONSTANTS
						C1 = 0000000001 New item code
						C2 = 8000000000 Single space code
						C3 = 9000000000 Double space code

FIGURE 17. PROGRAMMING FOR A NEW ITEM CHANGE CARD

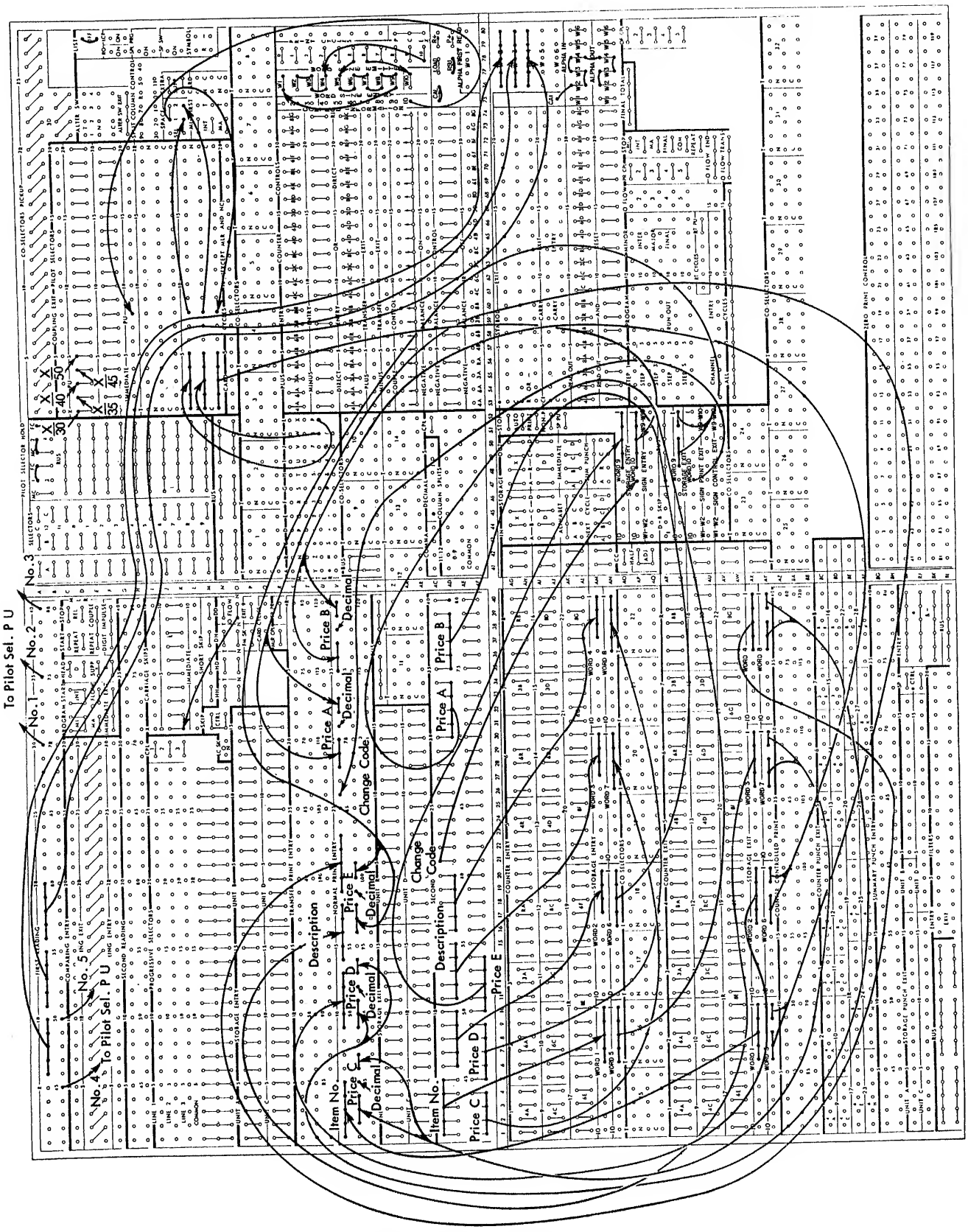


FIGURE 18. CONTROL PANEL WIRING FOR CHANGE LISTING

SUMMARY OF OPERATION CODES AND ADDRESSES

OP Codes	Abbr.	Description
03	RCT	Read and check a tape record.
04	RT	Read a numerical tape record into high-speed storage.
05	RTA	Read an alphanumerical tape record into high-speed storage.
06	WT	Write a numerical tape record from high-speed storage.
07	WTA	Write an alphanumerical tape record from high-speed storage.
08	LBB	Load a maximum of 10 words into high-speed storage.
09	LB	Load a maximum of 50 words into high-speed storage.
25	BNTS	Branch on no tape signal (EOF or error signal).
27	SET	Set the buffer at the address specified by the data address.
28	STBB	Store a maximum of 10 words from high-speed storage into general storage.
29	STB	Store a maximum of 50 words from high-speed storage into general storage.
54	BRNEF	Branch to data address for error routine when end of file condition is not recognized. Use 1-address for end of file routine.
55	RWD	Rewind the tape unit specified by the data address.
56	WTM	Write a tape mark on the tape specified by the data address.
57	BSP	Backspace specified tape one record.
70	RD1	Read — Input-Output Storage Area One
71	WR1	Write (Punch or Print) — Input-Output Storage Area One
72	RC1	Read Conditional — Input-Output Storage Area One
73	RD2	Read — Input-Output Storage Area Two
74	WR2	Write (Punch or Print) — Input-Output Storage Area Two
75	RC2	Read Conditional — Input-Output Storage Area Two
76	RD3	Read — Input-Output Storage Area Three
77	WR3	Write (Punch or Print) — Input-Output Storage Area Three
78	RC3	Read Conditional — Input-Output Storage Area Three

ADDRESSES

High-Speed Storage	Tape Units
9000	8010
9001	8011
9002	8012
9003	8013
.	8014
.	8015
9059	

OPERATION CODE TIMING CHART

THE CHART (Figure 19) presents the timing and interlock conditions for the high-speed storage, magnetic tapes, and printer operation codes.

It will be noted that there are three interlocks for the tape system: one interlocks the *buffer* (high-speed storage), one interlocks the *tape control unit* which controls all of the tape units, and one interlocks the particular *tape unit* addressed.

BI (Buffer Interlock). This interlock is set by the execution of operation code 04, 05, 06, or 07. Its purpose is to prevent a reference to any part of the high-speed storage while it is being loaded or written out to a tape unit.

The execution of either of the following instructions will be delayed until the buffer interlock is turned off:

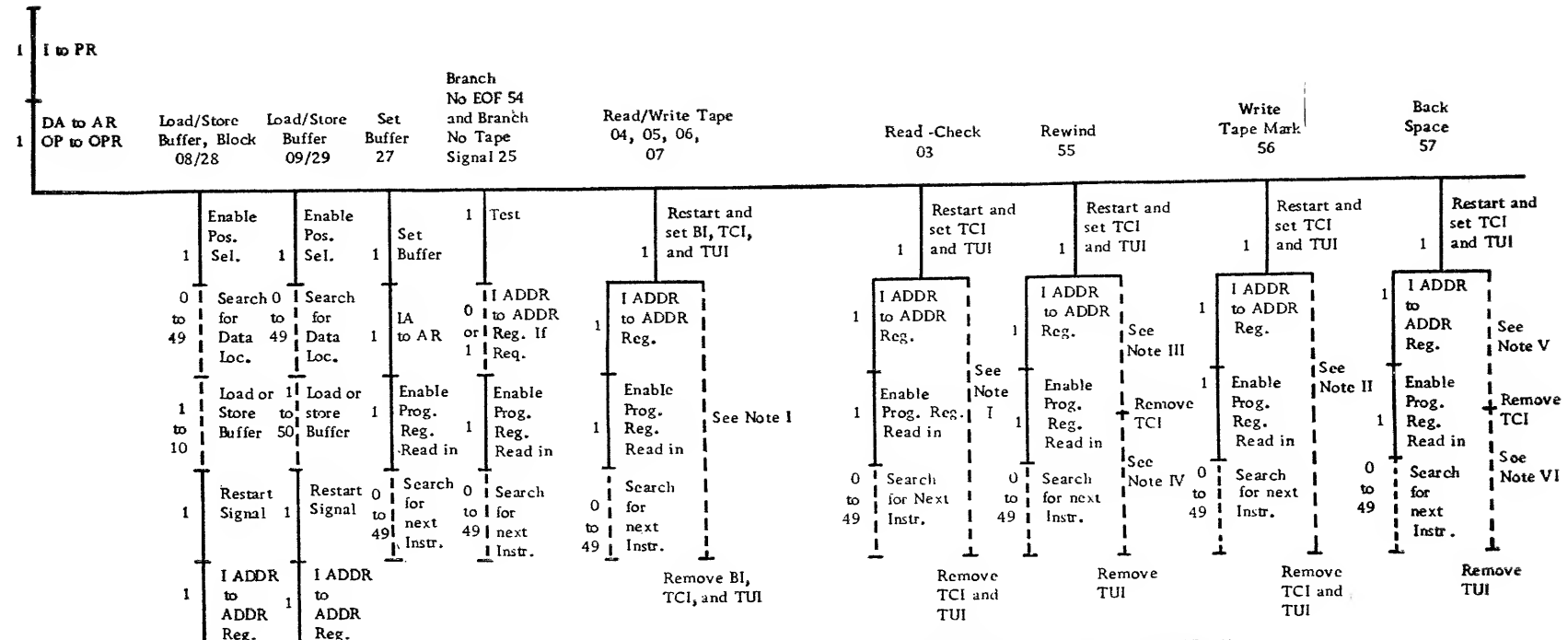
1. Any instruction having a data or instruction address of 90XX

2. Any instruction that enters the program register while the buffer interlock is on requiring a buffer to read in or read out.

TCI (Tape Control Interlock). This interlock is set by the execution of operation code 03, 04, 05, 06, 07, 55, 56, or 57. Its purpose is to prevent the use of the tape control unit or examination of the tape signal control, the tape error control, or the tape indicator until the current instruction is completed. If operation code 03, 04, 05, 06, 07, 25, 54, 55, 56, or 57 enters the program register while the tape control interlock is on, its execution will be delayed until the tape control interlock is turned off. Its execution may also be delayed depending upon the status of the tape unit interlock.

TUI (Tape Unit Interlock). There is one set of these interlocks for each 8010-8015 tape address. The particular interlock is set when the tape address to which it refers enters the address register. Its purpose is to prevent the use of that particular tape unit until the current instruction addressing that tape unit is completed. If a tape address appears in the address register while its particular tape unit interlock is on, the execution of the instruction will be delayed until the tape unit interlock is turned off.

An inspection of the timing chart will show that the TCI is turned off before the TUI for the Rewind and Backspace operations. For any other tape operation the TCI and TUI are turned off at the same time.



NOTE I - (10.3+.068N)ms.
(N is the no. of tape characters in the record)
NOTE II - 11.0ms.
NOTE III - 24.0ms.
NOTE IV - Approx. 1.2min.
NOTE V - If in Write Status (46.0+.068N)ms.
If in Read Status (30.0+.068N)ms.
NOTE VI - 24.8ms.

OP CODES FOR TYPE 407 OPERATION

TYPE 650 INTERLOCK TIME

	*650 Interlock Time In Milliseconds	
OP Code	Minimum	Maximum
RD	115 ms	505
RC	45	440
WR	55	450
RC/WR	150	545

*Interlock time variable between maximum and minimum limits due to random timing relationship between Type 650 and 407.

MAXIMUM AVAILABLE COMPUTE TIME BETWEEN SUCCESSIVE TYPE 407 OP CODES TO MAINTAIN 150 LPM*

OP Code	Milliseconds	Drum Revolutions
RD → RD	285	59
WR → WR	345	71
RC → WR	8	1-1/2
RC/WR → RC	250	52

*To maintain 75 cpm or 75 lpm; add 400 ms or 80 drum revolutions to the above table values.

FIGURE 19. OPERATION CODE TIMING CHART

650 ADDITIONAL FEATURES

Form 22-6265-1

Form 22-6265-1 (7-56:10M-JC 601)